Tappi

PUBLISHED BY THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY

SEPTEMBER 1955

VOLUME 38 • NUMBER 9

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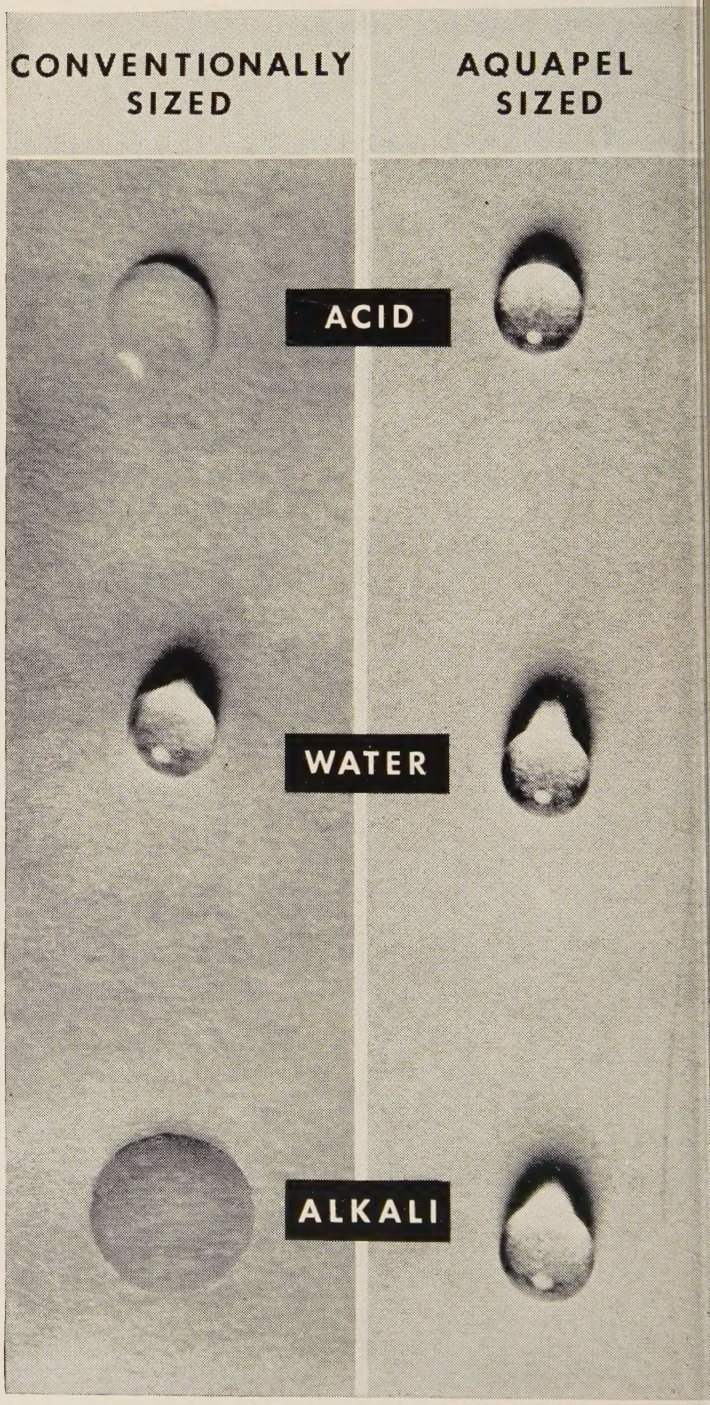

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PP55-6

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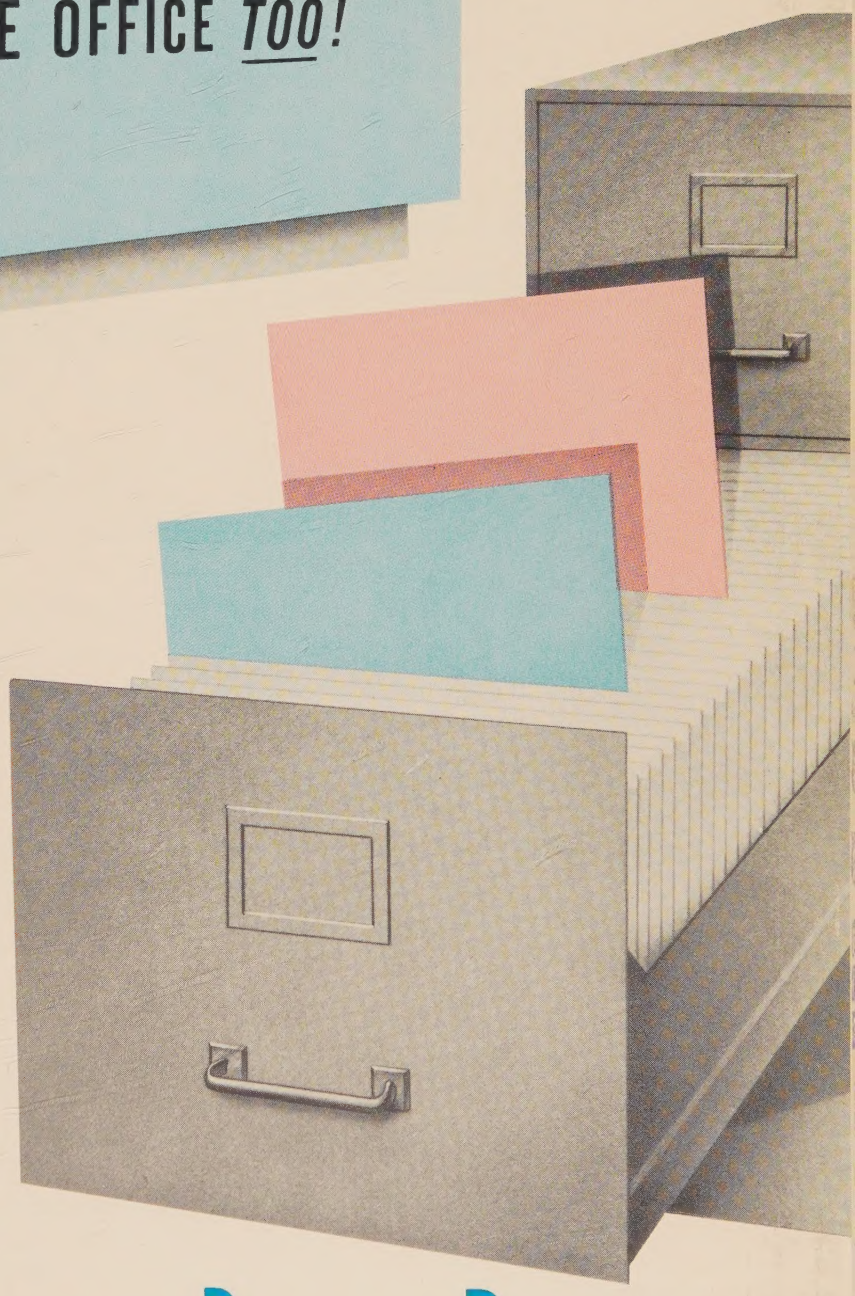

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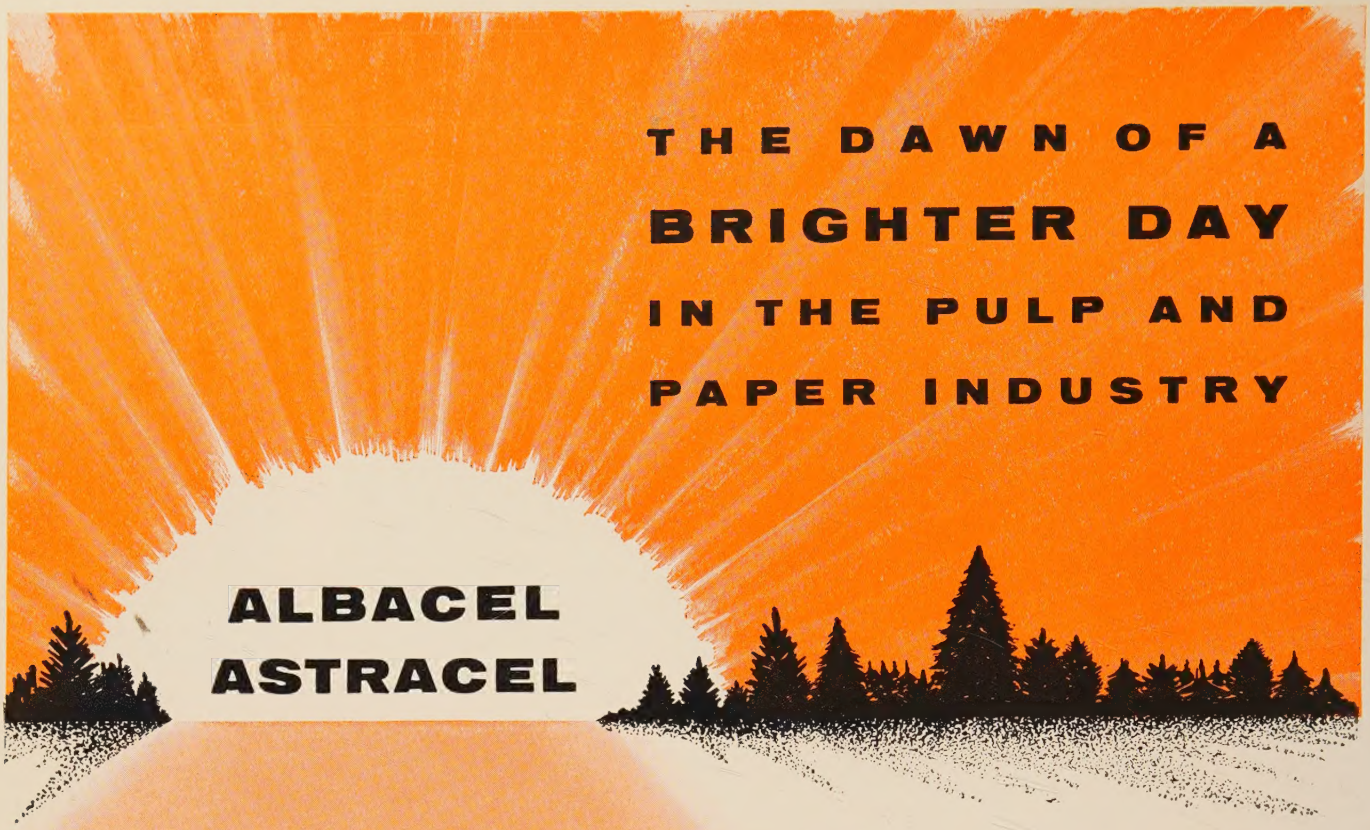

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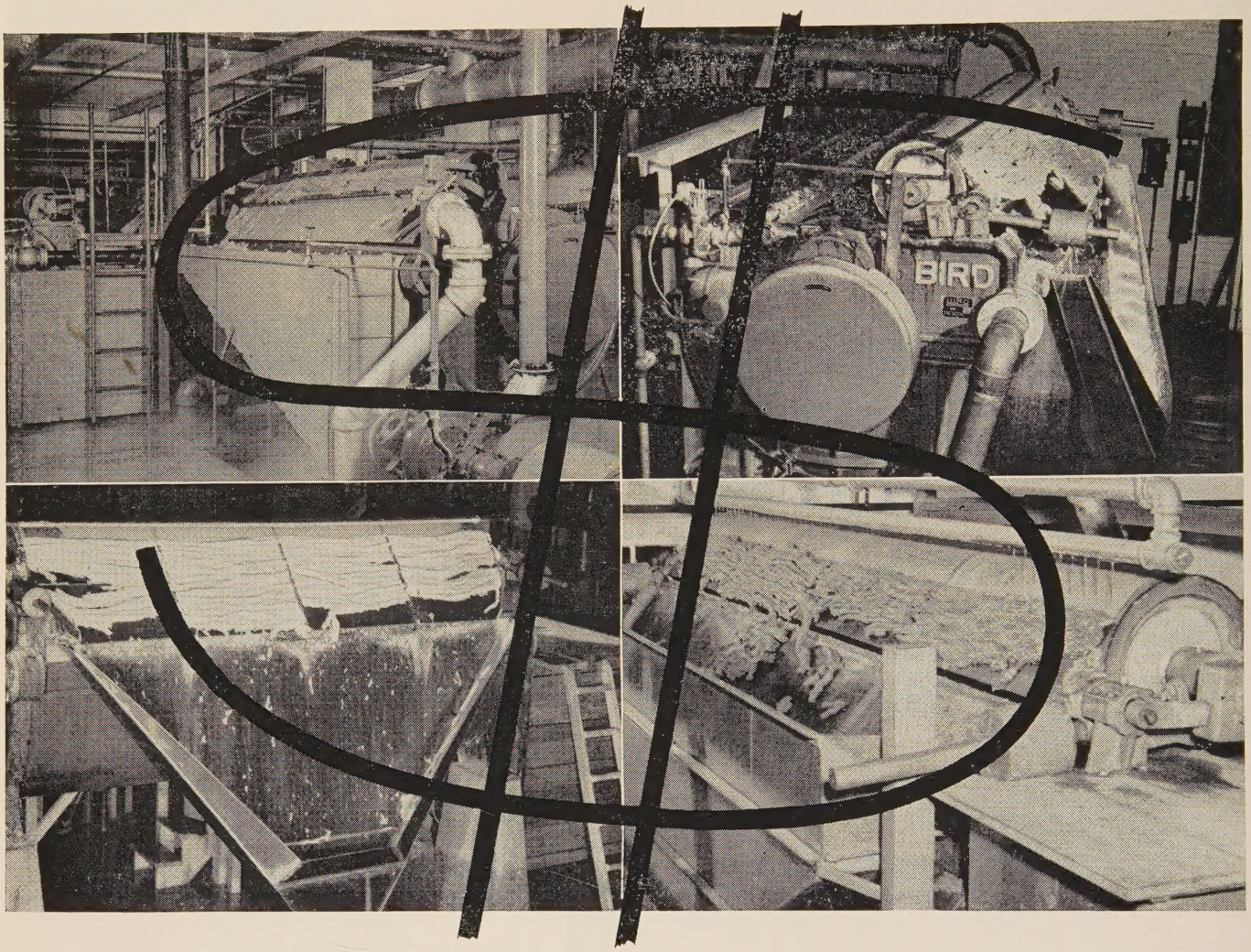

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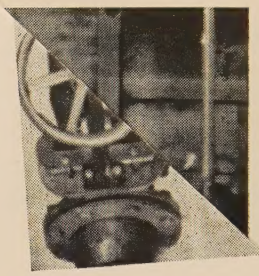

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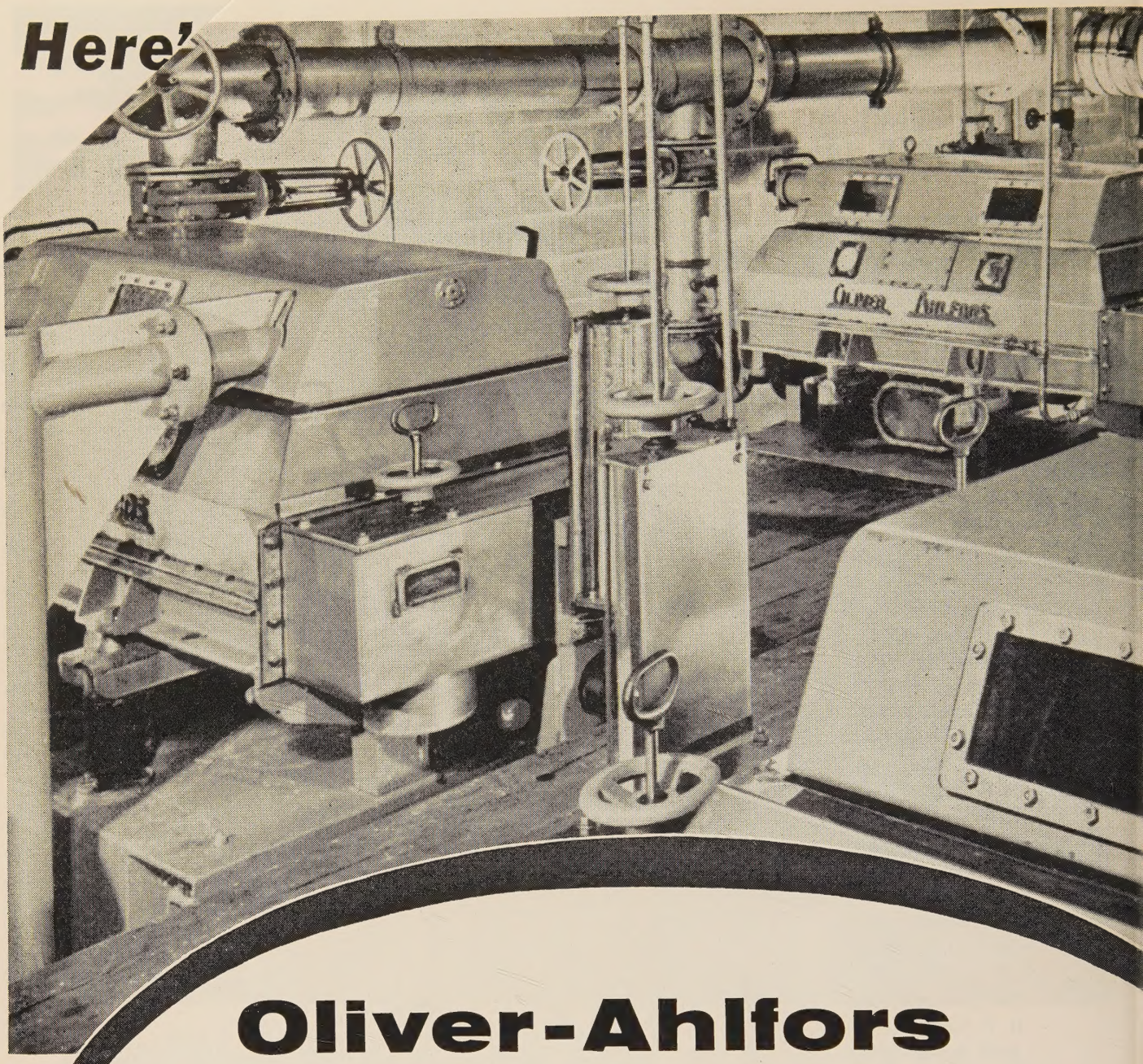
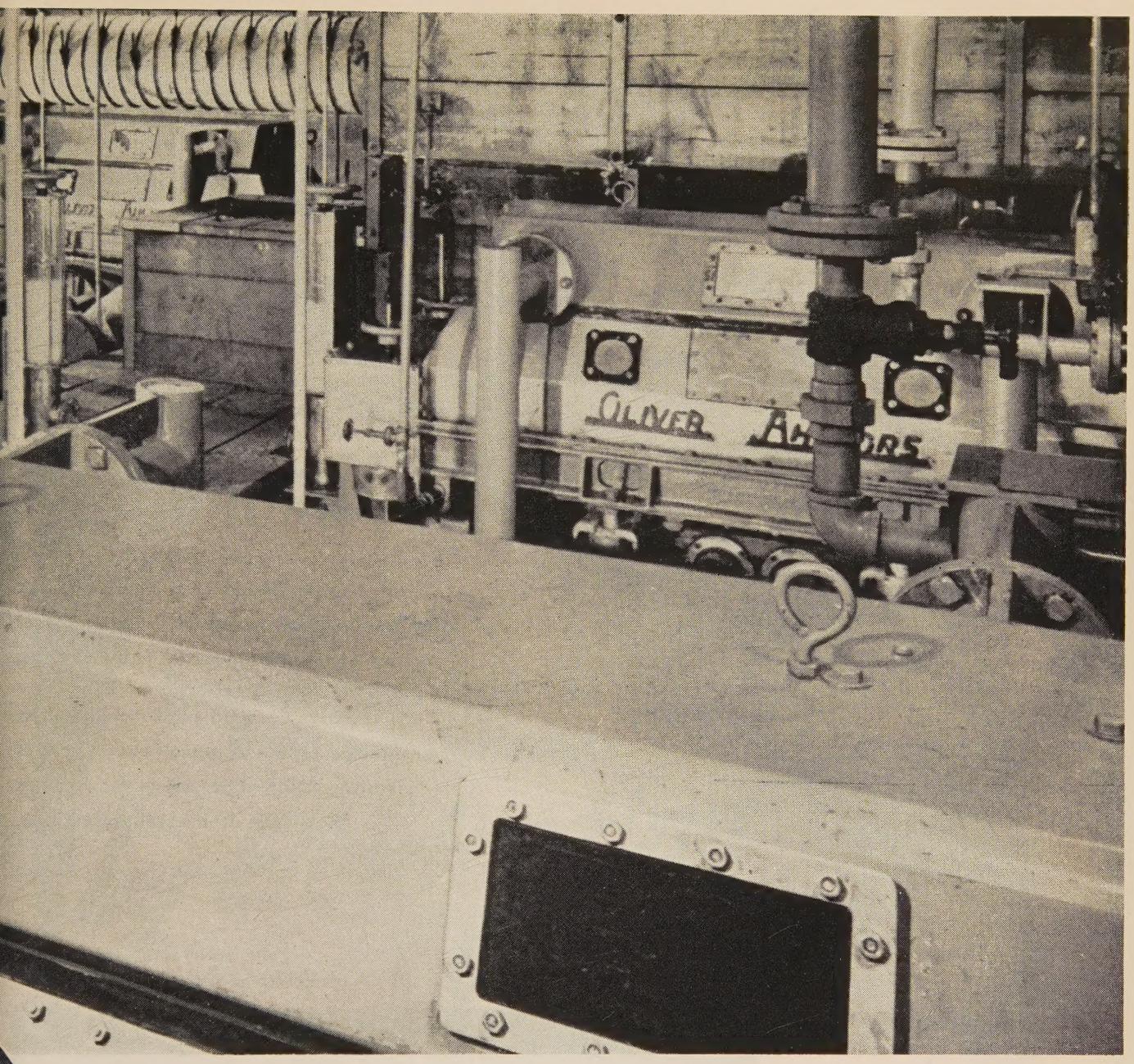


Oliver-Ahlfors Screens Handle 165 Tons of Paper Pulps Daily

in Large Washington Kraft Mill



This compact installation of Oliver-Ahlfors Pulp Screens is located in the St. Regis Paper Company's Tacoma, Washington mill. 165 tons of fully bleached kraft pulp are handled by these screens daily. Of the units shown, five are for primary and one for secondary screening.

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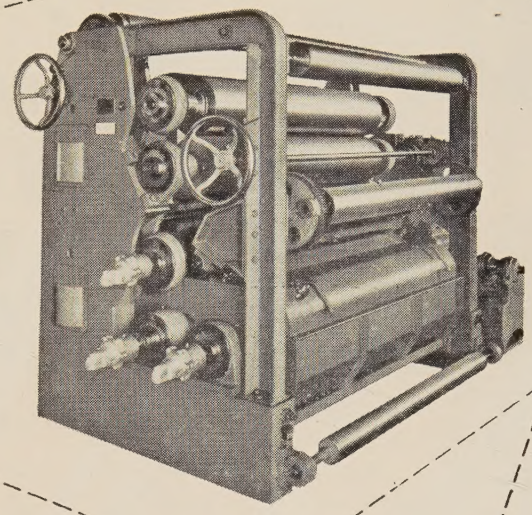

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Asphalt Laminator at
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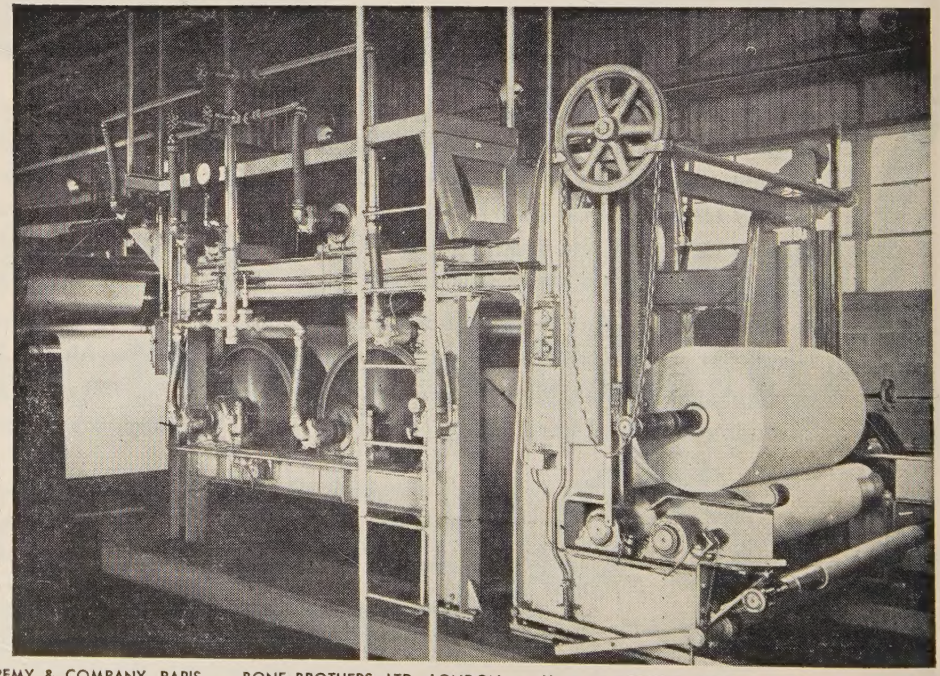

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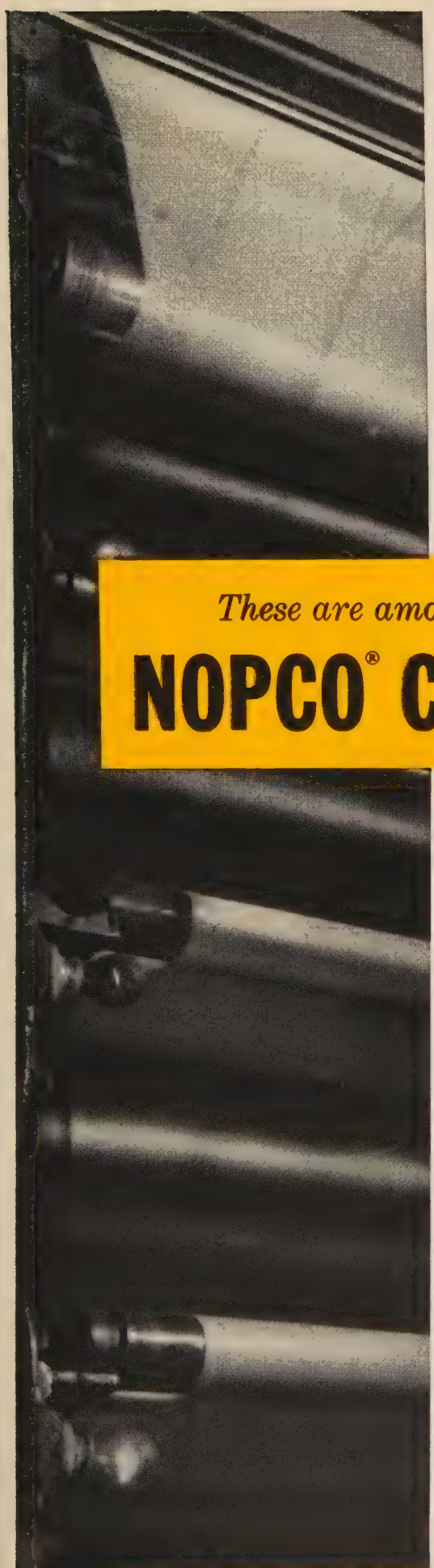

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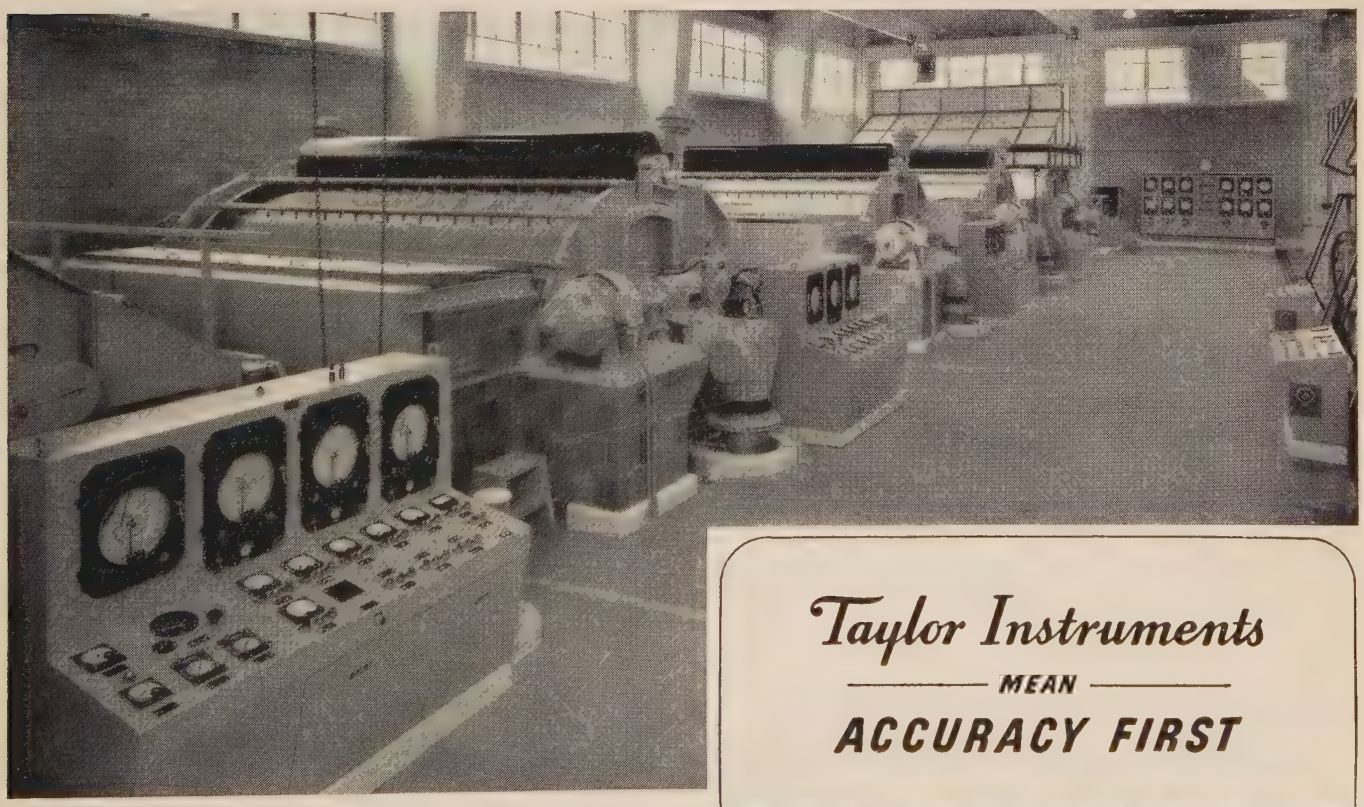

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The Engineer's Contribution to the Development of the Pulp, Paper, and Board Making Industry

ARTHUR BAKER

It is my privilege this morning to give the third John Stadler Memorial Lecture, and I should like to begin by paying a tribute to the memory of an old friend, the man these lectures commemorate, and I do so with greater pleasure, because I was instrumental in influencing John Stadler's career in a direction which ultimately led him to become a consulting engineer in Montreal, where his gifts and knowledge became available to the whole industry.

I have given this lecture the comprehensive title "The Engineer's Contribution to the Development of the Pulp, Paper, and Board Making Industry."

You may be interested to hear that in 1950, in the light of our experience of Government control in the United Kingdom during World War II, we changed the name of the Paper Makers' Association of Great Britain and Ireland to that of the British Paper and Board Makers' Association, and for the purpose of the construction of the Articles of Association, paper was defined as meaning all descriptions of paper, paperboard, wallboard, and fiberboard which are produced wholly or mainly either from vegetable fibers or a pulp thereof or both from such fibers and such pulp.

In 1828 a famous British civil engineer, Thomas Tredgold, defined engineering as "the art of directing the great sources of power of nature for the use and convenience of man." That still holds good for today if one bears in mind that the profession of engineer has been continuously extended to include civil, mechanical, electrical, and chemical engineering and other technologies which today administer to the comfort and well-being of mankind.

In reviewing progress in our industry, one cannot fail to be struck by the great acceleration in the rate of development during the first half of the Twentieth Century, more than maintained during the few years which have passed since the commencement of the second half. In the excellent textbook "Pulp & Paper Manufacture," prepared under the direction of the Joint Executive Committee on Vocational Education representing the pulp and paper industry of the United States and Canada, papermaking machines are classified in seventeen groups, ranging in size from 30 to 320 in. in width, with a range of speed from approximately 100 to 2500 f.p.m.

THE PAPER MACHINE

It is interesting to examine the development of the fourdrinier paper machine and in particular the newsprint machine, the type where, thanks to the enterprise and efforts of the engineer, probably the most striking advance of all has taken place.

Arthur Baker, Chief Technical Adviser, The Bowater Corp. Ltd., London, England.

When I entered the industry in England at the turn of the century, the width of the paper machine operated by the largest newsprint manufacturer in Great Britain was about 120 in. and the speed was approximately 250 f.p.m. A machine 100 in. wide, installed in 1890, was then running at 100 f.p.m.; by 1900 eight machines were running in the same establishment at an average speed of 230 f.p.m., but in that year two machines 155 in. wide to run at 420 to 475 f.p.m. were installed in the United States.

In 1909 the first suction couch roll was applied to a newsprint machine in Canada and its outstanding advantages were immediately recognized. A year later I was concerned in the successful application of a similar suction couch roll to a 104-in. machine, manufacturing writing paper in England.

In 1912 the first two-and-a-half-roll newsprint machine was installed in Canada. World War I intervened, but progress took on a quicker tempo after its conclusion with the installation of the first three-roll machine in 1919. There followed the controversy on speed versus width, two-roll versus three-roll machines, which inevitably ended in the installation of fast three-roll machines on the North American continent. I had the pleasure of installing the first three-roll machine in England, in fact in Europe, in 1922. Great Britain finally held the palm in 1934 with a four-and-a-half-roll machine designed to run at 1400 f.p.m.

Many factors and much ingenuity by engineers, papermakers, and others had contributed to the general advance. The influence of the Eibel method of working the slice, disclosed in 1907 had soon placed newsprint machines in a class by themselves as far as speed of operation was concerned. Eibel's patent provided for raising the breast roll above the horizontal in order to slope the wire down-hill, causing the stock to travel by gravity in the direction of the wire, and substantially as fast as the moving wire. This patent was the subject of extensive litigation from the beginning, although most of the larger newsprint mills were stockholders in the Eibel Process Co. or became licensees. It was finally declared valid by the United States Supreme Court on Feb. 19, 1923, but was ruled invalid in Canada by the British Privy Council. By its aid, speeds up to 750 f.p.m. were realized with a gate slice and the jacketed top couch roll.

About this time the rotary wet-vacuum pump made possible the use of suction couch rolls on wider and faster machines. Automatic compressed-air feeding methods were developed at the couch, presses, calenders, and elsewhere, which contributed to the increase in speed and this necessity actually rendered operation much safer for the machine tender than when he had to rely on manual dexterity at slower speeds.

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The removal of more water before the driers by weighted presses could not be realized at speeds much in excess of 1000 f.p.m., because the water was thrown back into the nip by centrifugal force; the suction press roll was, therefore, a natural development, and by 1921 two-roll machines were operating at 1000 f.p.m.

There followed the projection slice, the pressure slices, and all that was involved and with the more general use of suction couch rolls and suction press rolls, speeds of about 1600 f.p.m. were reached by 1948, while today, thanks to those who conceived the idea of the application of the suction pick-up roll, first applied England on tissue paper, we have passed the 2000-f.p.m. mark for newsprint production with 2500 ft. in the offing.

Of course, simultaneously with developments in connection with the newsprint machine, progress was made with machines designed for the manufacture of fine papers, tissue, wrapping paper, kraft liner, board, and machine-glazed papers.

Today the manufacture of tissue is approaching a speed of 3000 f.p.m., while a single kraft-liner machine can produce as much as 1000 tons of paper per day. But the basic principle remains the same with the formation of the sheet on the wire, the removal of water by draining, pressing, and drying.

As the design of the paper machine was improved and the speed of operation increased, sectional electric paper machine drives were introduced and attained widespread application. Over the years a host of improvements flowed from the engineers. To name a few, the application on an extended scale of antifriction bearings, rubber covered rolls, removable fourdrinier wire parts, carefully designed condensate water removal systems, consistency regulators, metering and proportioning systems, rotary screens, centrifugal cleaners, the employment of the electric eye for controlling the sheet at the wire when breaks occurred in other parts of the machine, vacuum and electric methods of sorting and counting the sheets of finished product and last, but not least, the application of electronic devices to give closer regulation in many directions not hitherto possible.

With the increase of speed came improvements in the ventilation of the paper machine room and particularly the movement of moist, saturated air at the drying cylinders. Later came the almost complete enclosure of the drying portion of some paper machines; while mills in northern climates saw the introduction of heat economizers specially designed for the recovery of waste heat as hot air or warm water.

These rapid developments were accompanied by improvements in the design of auxillary equipment such as winders, reels, supercalenders, handling equipment, and in transport throughout the mill.

IMPROVED PULPING PROCESSES

The methods of obtaining the beating effect came under close scrutiny, particularly in the mills producing wrapping paper, greaseproof, and glassine. Changes were effected in the construction of refiners designed to encourage a less reliance on the beater, and proposals for the continuous treatment of stock received closer attention.

Parallel with those developments came a better appreciation of the need for the examination of the pulping processes for the production of groundwood and the manufacture of chemical pulp.

Until the early studies on the grinding of wood for pulp were made in the Forest Products Laboratories of Canada and the United States, there was little exact knowledge of the groundwood process, and the main conception and practice of the process continued substantially unchanged for many years. One might have expected that, in view of the development in the speed of the newsprint machine, there would have followed wider differentiation in the quality required for groundwood pulp with a more strictly defined specification according to the intended use, but this has not occurred to any extent and the gradual achievement of a higher degree of uniformity with a reduction in shive content has equally benefited all grades of paper with a high groundwood content.

The near future should see a determined effort to improve existing techniques with suitable methods of testing to conform with the performance of pulp on the paper machine.

A lead is held out from Norway, where a departure from the conventional grinding technique has recently been introduced, which allows the stone to be run free without immersion in the stock and with a considerably increased specific load on the grinders.

With the aid of the engineer one may expect to see a major increase in the production per grinder unit in the years to come.

A limiting factor against the use of higher loads and speeds has been the physical resistance of the grindstone to these increases, because the heat generated by the grinding process must be dissipated in some way without damage to the pulp quality or the surface or structure of the grinder itself. We can, therefore, expect new departures in the composition and construction of artificial stones.

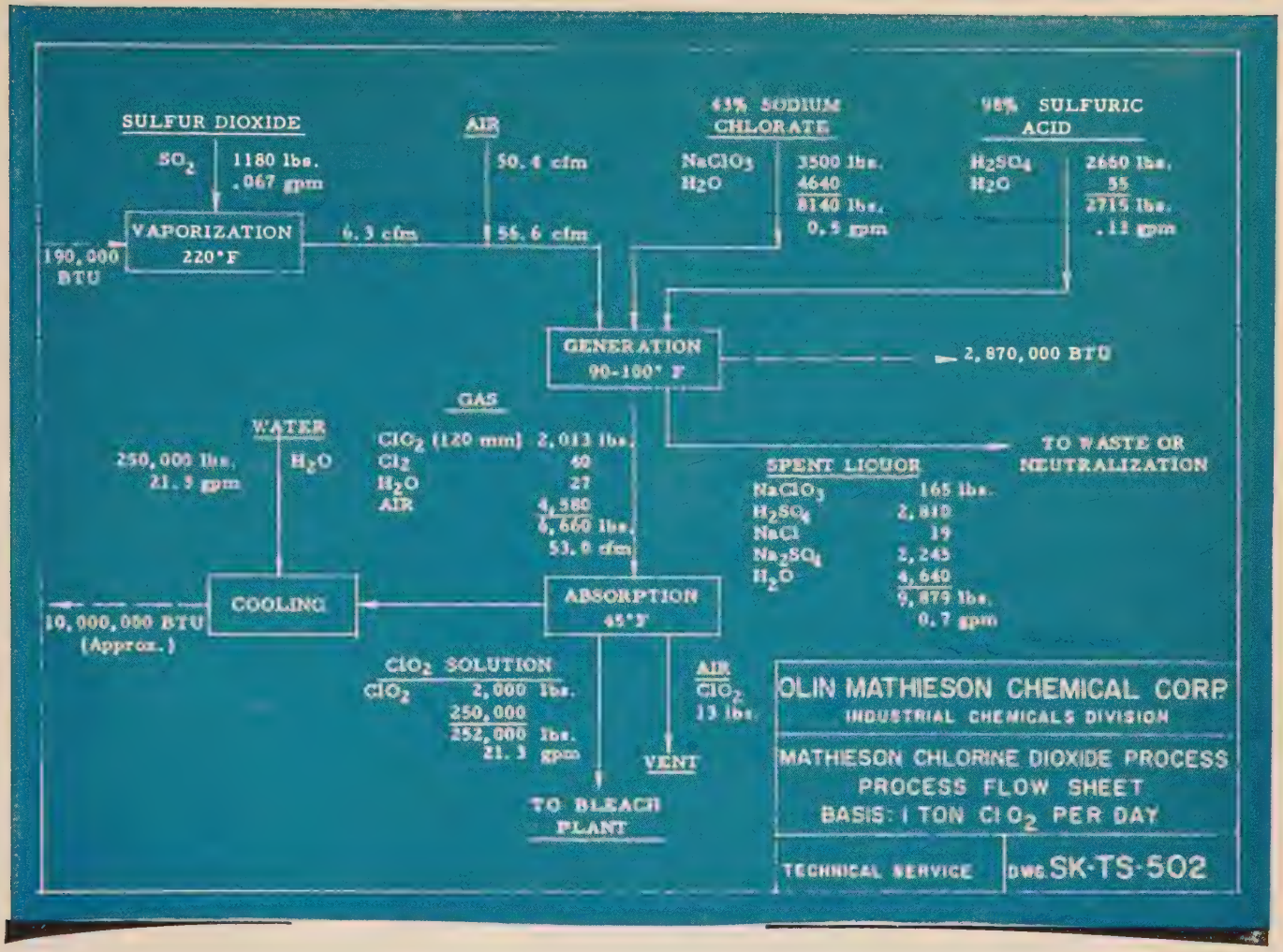
The vast amount of energy transferred into heat during the grinding process has frequently been under consideration. This heat is completely wasted because, so far, the relatively low range of temperature has prevented utilization through heat pump or other means. A step in the right direction has been taken in some groundwood mills producing pulp for export in Norway, where reclaimed heat has been harnessed for the heating of buildings and hot water.

Most raw materials for paper manufacture contain from 40 to 50% of cellulose, the rest being composed of lignin, fat, resin, pectin, etc., extractable by digestion with chemicals under suitable conditions of treatment, during the production of chemical pulp.

It was felt, however, that the sulphite process could not be said to have reached its economic basis so long as there was a colossal loss of wood substance, such as, lignin, etc., in the waste liquor.

Recovery processes made the alkaline treatment of raw materials a commercial success, and the outstanding kraft process, though bringing corrosion troubles in its train, widened the field of raw materials to a significant extent.

The industry is indebted to the engineers responsible for the marked improvement in the design and methods



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of construction of recovery boilers which has had an appreciable effect on costs of operation.

Later came the continuous processes for the treatment of straw and other materials, calling for much ingenuity in the design of suitable plant, developments in the application of methods to produce high-yield sulphate pulps, the so-called semichemical treatment, and later the neutral semichemical processes, applied to a wide field of raw materials foreshadowing the utilization of hardwoods on a large scale.

Hardwood pulps of this type will, undoubtedly, come into general use with aid of precision-built pulpers and refiners designed to have little or no cutting action. These pulps will have a low wet-web strength, but this drawback will be neutralized on the fast running machine by the extended use of suction pick-up rolls.

Bound up in the economics of their use is the matter of chemical recovery in the semichemical spent liquors. Methods of recovery are in the course of development, but at present the problem is being met in some mills by using the spent liquors as a chemical make-up in the existing recovery system of associated pulp production.

As the knowledge of the behavior and possibilities of these pulps increases, there will be increasing interest by the non-integrated paper and board mills, and I foresee a fruitful field for collaboration between the engineers and technologists.

In the main, the paper machine of today is ahead of the stock preparation end, but technologists and engineers will bridge the gap, possibly by revolutionary changes demanding the highest engineering skill.

STOCK PREPARATION

The complex effects produced in the beater, which I prefer to call "the beating effect," is a subject of itself. In spite of the high power consumption per ton of product, the hollander-type beater and its modifications, with all its faults, still finds application in fine paper mills and the mills making specialty papers which are not fully integrated, but there is, nevertheless, a definite changeover to refiners in certain directions. The British Paper and Board Industry Research Association has made the Pulp & Paper Research Institute of Canada and the Institute of Chemistry, Appleton, acquainted with the research work we are carrying out in the United Kingdom on the structure of fibers with the aid of conventional and electron microscopes, which may have an important bearing on future developments.

USEFUL APPLICATION OF RESEARCH

As a result of the progress in fundamental science in many directions and the practical application of scientific methods and new discoveries, there has been an immense development in the variety and kinds of machinery, large and small, in which our industry has shared.

While it may appear to some people that the world is more ready to use science, engineering, and invention for destructive purposes than for social progress, that view is based on a misconception. It is a fact that many of the agents used for destruction during the two world wars were created as a result of the experience gained in times of constructive effort, the new factor being the provision of money and facilities for research on an enormous scale, and there is a lesson for the industry.

We are all aware that many of the notable achievements in industrial development have been produced by teams of research workers including physicists, chemists, and engineers who had been given facilities and sufficient money for research.

Ideas which flow from the research laboratories should be taken by industry promptly through the stages of development and production, and we should see to it that the facilities and resources both for fundamental and applied research are adequate. I am never tired of telling our people in the United Kingdom that our industry must be quick off the mark in utilizing the results of applied research.

Sustained progress will depend on the growth and application of new knowledge, but the solution of many technical problems immediately facing the industry must be sought in the application of existing knowledge. Much of the new knowledge on which further progress will depend must spring from long range fundamental or pure research. There is the source of the new ideas which finally lead to substantial advance in practice.

Sir J. J. Thomson once said, "Applied research leads to improvement, but research in pure science leads to revolution."

Industrial research should be objective and consist of long-range attacks on basic problems that fall in our particular field, even if only to obtain an insight into such basic phenomena as the "beating effect." That is often the shortest route to the solution of problems of practical importance.

Paper manufacture, like many other industries, up to a certain stage developed without the aid of the technical man; often, practical results long preceded the theoretical explanation. Manufacturers were very jealous trade rivals, and feared the extension of any movement which might enable others to grasp what were considered as trade secrets. But with the founding of the Verein der Zellstoff und Papier Chemiker in Germany in 1905, of TAPPI in 1915, of the Technical Section of the Canadian Pulp and Paper Industry a little earlier, and the foundation of the Technical Section of the British Paper and Board Makers' Association in 1920, a change began which has steadily gathered momentum until, notwithstanding the setbacks of war, we have reached the stage when it is possible to hold international meetings of the kind we have here today. There is much to be gained from reciprocal visits and interchange of ideas, both from an individual and a national point of view. All the wit of the world is not in one head. "Wit sharpeneth wit."

A field in which the technologist can play an important part is in the conservation and careful use of water. Industrial water has become one of our most precious possessions, the indispensable resource on which plans are so often based. In some parts of Europe and North America water has, or is becoming, the limiting factor to development and in certain coastal areas dependent on well water, both in Europe and North America, the intrusion of sea water into the water table has become serious.

Europeans are always surprised at the prodigal use of water in industry on the North American continent.

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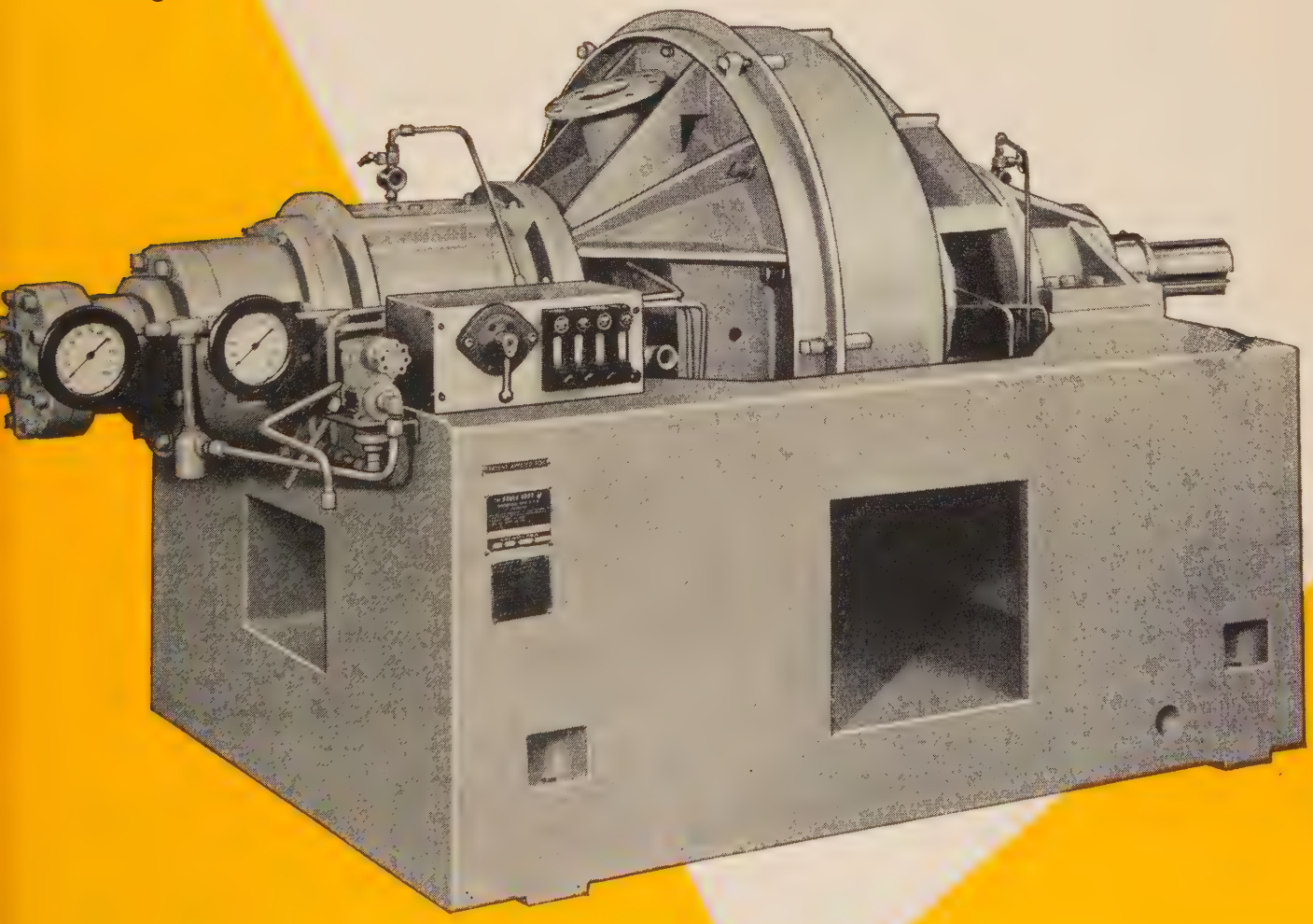

Technical men can do much to bring about its more efficient use. Its conservation should have high priority. Much can be done by the efficient treatment of effluent, the reuse of water or even by returning well water, used for cooling, to the strata from which it was drawn.

STEAM AND POWER PRODUCTION

Owing to the requirements of steam for digestion and drying purposes, the pulp and paper industry was early in the field in the use of back-pressure steam engines and steam turbines, a certain amount of power becoming available as a by-product. But the time appears overdue for a close examination of the enormous power consumption of the vacuum pump installations at the wet end of many paper machines.

There have been great advances in the design and construction of steam raising plants, both in the size of the unit and the pressure at which steam is generated, which will lead to high overall efficiency.

The world has seen hydroelectric development on a large scale and here in Canada, as a result of the imaginative development of hydroelectric power, the Province of Quebec has seen a great industrial development. The paper industry in Canada has benefited very much by the exploitation of such possibilities, and there are plans for a vast increase.

The development of nuclear energy will, however break new grounds for civil and industrial users.

It is estimated that the cost of electricity generated from a prototype thermal reactor in the United Kingdom will be in the neighborhood of a penny a unit, which is about 50% higher than the average cost of power generated from coal-fired power stations in Great Britain at the present time. It should be possible to reduce this figure to about 0.8d. per unit when experience has been gained from a few large installations. There is every indication that the cost of coal will increase, and therefore it would not be surprising if, in a relatively few years nuclear power became competitive in the United Kingdom; but many stations working on different principles will have to be built and tested until is is found which is the most reliable and economic. You may have heard of the first civilian project to be licensed in the United States under the Atomic Energy Act. It is to be constructed on the campus in Ann Arbor, Mich.—an indication of things to come.

Since it is estimated it will cost about 3000 million pounds to build up a nuclear electricity system comparable to the present generating capacity in the United Kingdom (20,000 mega-watts), it can hardly be less than 20 to 25 years before such a nuclear system would be possible in the United Kingdom, and, therefore, allowing for the development period, one can hardly expect such a system in action before the end of the century. But in the United States and Canada progress will be much more rapid, perhaps remarkably so, possibly startling.

Ultimately nuclear energy will make possible the provision of large or medium-sized power stations in out-of-the-way places, to which the transport of conventional fuel is either impossible or prohibitively expensive. Thus there is every indication that, while by the end of the century, nuclear energy will have made its mark in our power pattern, the underdeveloped countries will have felt its impact much earlier.

Some underdeveloped countries are often underdeveloped just because they have no power available; the impact of nuclear energy on them is bound to be considerable. It will make increased industrialization feasible by tending to equalize the cost of power over the world and so enable industries to be set up in places deprived of the conventional fuels.

Regarding the materials of construction, the use of such non-corrosive and hard-wearing materials as titanium not only for the paper machine itself, but also for machine wires, is a likely development. Titanium has many advantages as a material of construction over iron, brass, and copper, and it is anticipated both in America and the United Kingdom that within 10 years the metal will be almost as cheap as aluminum. Of course, its general or extensive use will demand new techniques in welding, wire weaving, and other applications.

The discovery of lubricants which are stable over higher ranges of temperature, like the silicones and polyfluorethylene and the use of special bearings which can carry the liquid lubricant, open the possibility of higher speeds and higher bearing temperatures than hitherto. The use of materials now in their infancy, which may be employed in the form of pre-formed bearing shells containing such substances as graphite and therefore self-lubricating throughout their life, is likely to grow. Such bearings have the advantage that they can be very easily changed and do not require the physical effort required to change roller bearings.

INSTRUMENTATION MAKES ITS MARK

The use of such instruments as the stroboscope which enables operators to actually see what is happening on the paper machine wire will become common, coupled with the use of high-speed photography.

Electronic instruments of all kinds, and, in particular, radioactive tracers, are also in their infancy. The instrument engineers and technologists will, in time, devise instruments to control the rate of drainage on the wire, the pressing and the drying on the paper machine, as well as the thickness, the moisture content, and properties of the finished sheet on a fully automatic basis.

In industry generally, progress in instrumentation and in the technique of servomechanism has led to the widespread application of automatic control to machines and continuous processes, which were not originally designed with this end in view.

Sir Harold Hartley has recently pointed out in the United Kingdom that: "Information from the United States and the Soviet Union is strong evidence of the much greater awareness of the urgency of this problem in both countries. In the United States there are said to be nearly 2500 companies in the control business employing 8000 graduate engineers who have specialized in this field, and there are 15,000 more in the user industries. In 1951, Russia was operating the first complete automatic production line of an aluminum-alloy piston from the ingot to the finished product fully tested and examined. In 1948 she had automatic plants making cylinder blocks and also agricultural machinery. Her automatic tests of surface finish are said to be most effective and ingenious. Evidently her

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3. Smooth processing. You'll find it helpful to work with the supplier's technical service men who visit you periodically. Often these men can spot potential problems and ward them off before they cause you trouble.

4. Safety programs. Your men can benefit from safety suggestions offered by your supplier. You should have on tap the latest in safety equipment, plus up-to-date information on safe handling of chemicals.

5. Economy. Choose a supplier who wants to help you cut your operating costs; who will go all the way with you in arriving at the best, most advantageous method of shipping and handling for your conditions.

6. Experience. Above all, choose a supplier who is familiar with your industry. It takes years of experience to acquire an understanding of the problems you face, and the know-how to help you solve them quickly and economically.

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THE PAPER INDUSTRY—A WORLD LEADER

We are engaged in a very important basic industry. According to the statistics, the world paper consumption averaged 47 million tons during 1950–52 and is estimated to average 65 million tons by 1960–62. In 1953 the combined production of paper and board in the United States, Canada, and Western Europe was approximately 40 million long tons, and it is calculated that in the United States alone the consumption will almost double by 1975.

The per capita consumption in 1953 was as follows:

United States	392.4 lb.
Canada	248.3 lb.
Europe (O.E.E.C. countries excluding Turkey)	85.3 lb.

This suggests that steps will have to be taken to increase the mechanization of forestry operation wherever it is economically possible.

There are likely to be some striking changes in the near future, including the production of certain types of paper and board without the use of water. Already the experimental stage has been passed, and production is on a commercial scale in the case of board.

These and other innovations stress the value of the imaginative mind. Physical labor by operatives must diminish and to an ever increasing extent muscular effort must be replaced by generated power. It is clear that the quality of the operative must be improved and the time is not far distant when the machine tender will be of the graduate type if the best use is to be made of generated power and the labor-serving facilities which will be put at his disposal. Installations will tend to become more and more expensive from a capital point of view, but less and less expensive from an operating point of view.

Finally, you must be aware of the world-wide pressing need in all industry for first-class administrators with a flair for leadership, with a capacity for independent, but logical thought, and possessing good sense and judgment.

These are the qualities which an engineering education, academic and practical combined, is well able to develop, but one must be more than an engineer, have a longish period of experience as an actual "doer", be able to take the broad view, be sympathetic to labor, and appreciative of the value of personal relationship. Above all, the captain of the team must have vision, respect for facts not opinions, be of intellectual integrity, and unrelenting in the search for truth.

No business can stand still. The keys to prosperity include the encouragement of research, discovery, and invention, the application of which in the hands of competent engineers, technologists, and administrators will attract the vast amount of new capital required to finance continued expansion. These keys must be used to unlock the doors to continued and undreamed of prosperity in our industry.

The Third Stadler Memorial Address presented at the Summer Meeting of the Technical Section of the Canadian Pulp and Paper Association, Quebec, Que., June 6, 7, 8, 1955. Reprinted in *Tappi* by permission of the *Pulp & Paper Magazine of Canada.*

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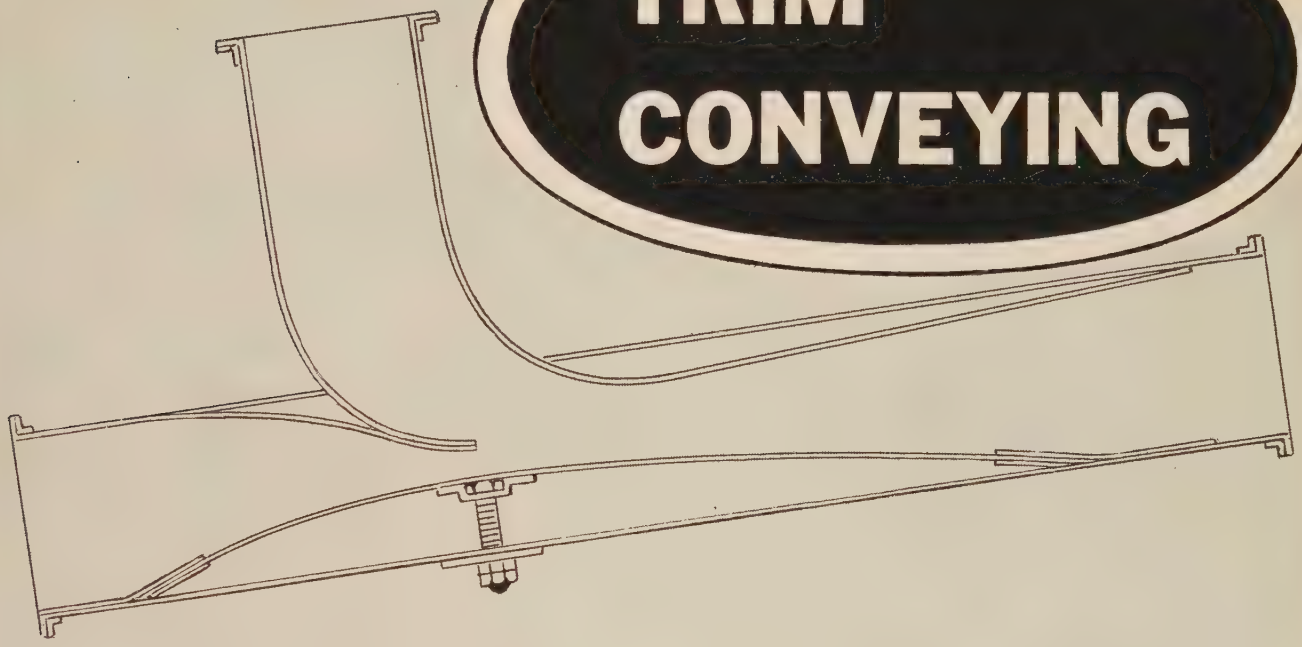

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Comparative Beating Investigation with Different Laboratory Beating Apparatus for Pulp Evaluation

TORSTEN EKSTAM

Comparative beating investigations have been carried out with five bleached sulphite qualities, two unbleached sulphite qualities, and three unbleached sulphate qualities in the Aylesford laboratory beater, the PFI mill, the Banning Seybold beater, the Valley beater, the Noble & Wood cycle beater and in the Lampén mill in five research laboratories in England, Finland, Norway, and Sweden. The pulp, sent to the laboratories by the Central Laboratory in Finland was beaten and formed into sheets according to the method of each particular laboratory as well as according to the British method (TAPPI Standard T 205). The testing of all sheets was done in the Finnish Central Laboratory. From the investigations it was evident, that the strength values of pulp according to the method of the various laboratories were of different order of magnitude, partly due to differences in the sheetmaking conditions, especially the wet pressure, but mainly due to the beating apparatus. All the beaters grade the pulps investigated, with the exception of the softest bleached qualities, in the same order in respect to the strength properties, independent of whether these values have been determined for sheets made according to the British method or the method of the particular laboratories. As a whole the grading of the unbleached sulphites and sulphates on the basis of the beating time at any given wetness is equal in most of the beating apparatus the grading of bleached sulphites however not being satisfactory. The PFI mill and the Valley beater (according to TAPPI) give strength values in good agreement with each other when the results are compared on a wetness (S.-R.) basis, which can be referred to the equal type of beating. The Aylesford beater and the Banning & Seybold beater give tensile, burst, fold and opacity-values in fairly good agreement with each other but this is not the case when tear, apparent specific gravity, and air permeability-values are considered. The Aylesford beater gives lower tearing strength, higher apparent specific gravity, and denser sheets than the B & S beater. The Lampén mill gives lower opacity values for all pulps than are obtained at the same wetness with barred beaters. The Aylesford beater and the B & S beater reduce the opacity figures least. The Lampén mill has, furthermore, a tendency to overbeat very soft pulps and the strength values of these pulps in relation to those obtained for stronger pulps are lower than in the other beaters.

SINCE there is no universally accepted standard method of pulp evaluation, any differences of opinion, between the pulp manufacturers and the pulp consumers, in the assessment of the quality of a particular delivery of wood pulp cannot be satisfactorily settled.

In view of this, while visiting the Scandinavian countries in the summer of 1947, J. Gartshore, of Albert E. Reed & Co. in England suggested the idea that a comparison between the pulp evaluation methods of different countries might be considered. The technical director of the Finnish Cellulose Union, T. Lassenius, adopted Gartshore's idea and suggested in November, 1947 that the Centrallaboratorium Ab in Helsingfors should try to re-establish a previous collaboration in the field of strength testing with Norwegian and Swedish pulp research institutes and to organize comparative beating investigations with these institutes as well as with the Central Laboratory of Albert E. Reed & Co. Ltd. in Aylesford, England.

In March, 1948, Lassenius and the managing director of the Centrallaboratorium Ab in Helsingfors, B. Nybergh, visited the Central Laboratory of Albert E. Reed & Co. Ltd. in England. Papirindustriens Forskningsinstitutt in Norway, and the research laboratory of the Svenska Cellulosa Ab in Skönsmon and the pulp mill laboratory of Korsnäs Ab in Gävle in Sweden. The purpose of these visits was to investigate, on the basis of a proposed scheme worked out by the Centrallaboratorium Ab, the possibilities of undertaking beating research with the aim of comparing different laboratory beaters.

At a meeting in England between representatives of the above-mentioned research institutes, it was decided to carry out the comparative beating investigations proposed by the Centrallaboratorium Ab, and the directors of research of the participating institutes were nominated to forward the question.

The scheme for a research program proposed by T. Ekstam at the Centrallaboratorium Ab was, after minor alterations and additions, agreed upon by all parties and it was possible to begin the beating investigations in December, 1948. The Centrallaboratorium Ab assumed the responsibility for carrying out all testing of the hand sheets, since it was considered necessary to perform the testing at one place. This testing work, however turned out to be far more extensive than was originally conceived and the work was therefore not completed until the beginning of October, 1951. The number of beating points, the strength properties of which were determined, totalled 2600 and about 13,500 sheets were tested.

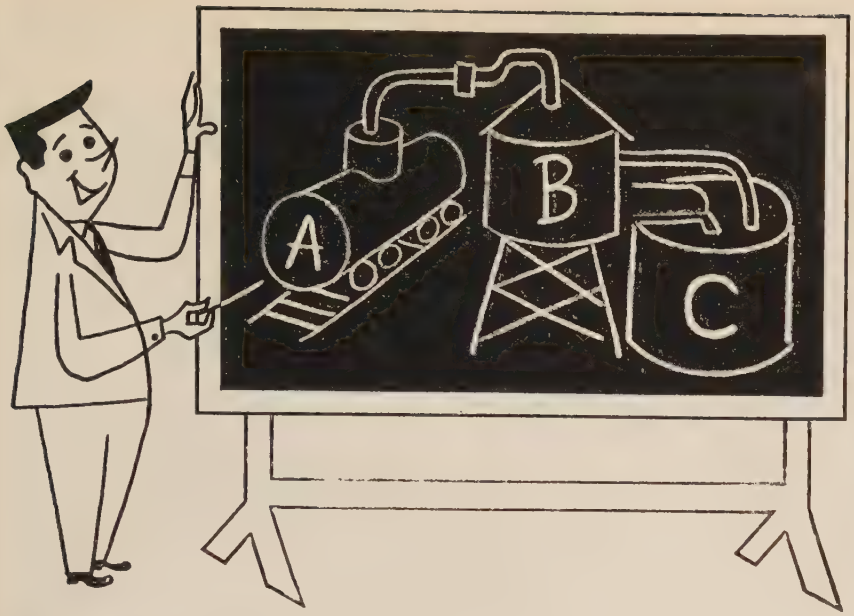
The purpose of the beatings was:

A. To investigate the relationship between the results obtained in strength testing of pulp in different research laboratories and the manner in which the different beaters grade the different pulp qualities according to sheetmaking methods used in these particular laboratories.

B. To investigate the beating performance of the various laboratory beaters when one standard method of sheet making is used, namely, the British method.

T. EKSTAM, Head of the Strength Testing Department, Oy Keskuslaboratorio—Centrallaboratorium Ab (The Research Institute of the Pulp and Paper Industry), Helsinki—Helsingfors, Finland.

Cooperative investigation carried out by: Albert E. Reed & Co., Aylesford Paper Mills, Aylesford, England. Director of Research: Leslie G. Cottrall; Papirindustriens Forskningsinstitutt, Oslo, Norway. Director of Research: Erik Stephansen; Svenska Cellulosa Aktiebolagets Forskningslaboratorium, Skönsmon, Sweden. Director of Research: Hilding Tydén; Korsnäs Aktiebolag, Cellulosafabrikernas laboratorium, Gävle, Sweden. Director of Research: Wilh. Rosén; Centrallaboratorium A.B. Helsingfors, Finland. Director of Research: Bertil Nybergh.



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A reduction in the viscosity of coating colors is gained by the use of small amounts of AZITE® Liquefier. Applied to both casein and alpha protein colors, an eastern mill reduced viscosities by 43% measured at slow Brookfield spindle speeds and 25% at high speeds.

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Pitch dispersing effect is noted by a midwestern mill when PAREZ® 607 Resin is used instead of a urea resin. Whenever pitchy wood is run with 607 also in the furnish, the 607 evidently deposits the pitch on the fiber so no sticking occurs in the system. With urea, pitch trouble continued.

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TEST CONDITIONS

Pulp Qualities

In the beating investigations different types of wood pulp were used, i.e., bleached and unbleached sulphite pulp and unbleached sulphate pulp and the qualities chosen from the different types ranged from very strong to very soft pulps.

The pulp qualities beaten were:

Extra strong	*Brightness 70.6*	*Viscosity (TAPPI) 47*	*Viscosity (Cu(En)/) 210*
Bleached Sulphites			
Strong	78.4	31 1/2	105
Soft	82.6	15 1/2	42
Rayon	86.5	19	46
Aspen	82.9	18 1/2	55
Unbleached Sulphites		*Roe No.*	
Extra strong		9.4	
Easy bleaching		1.5	
Unbleached Sulphates			
Kraft		5.3	
L & S		3.0	
Easy bleaching		1.4	

Sampling

The various pulp qualities were provided by the Centrallaboratorium Ab in Helsingfors, and samples were sent to the other laboratories. The pulp sheets were conditioned by hanging freely exposed to air of room temperature for some months to allow any changes in dry matter content and strength properties to stabilize. Every sheet was divided into 10 equal pieces and every piece was marked in the following manner.

Sheet I	*Sheet II*	*Sheet III*	*Sheet IV*
A B C D E	J A B C D	I J A B C	H J J A B
J I H G F	I H G F E	H G F E D	G F E D C

and so on.

THE BEATING APPARATUS

In the comparative beating investigations the following beating apparatuses were used.

Aylesford laboratory beater at A. E. Reed & Co., Central Laboratory, Aylesford, England.
PFI mill at Papirindustriens Forskningsinstitutt in Oslo, Norway.
Lampén mill at Papirindustriens Forskningsinstitutt in Oslo, Norway.
Banning & Seybold beater (Type SCA) at Svenska Cellulosa Ab, Research Laboratory Skönsmon, Sweden.
Valley beater (Swed.) at Korsnäs Ab's Research Laboratory Gävle, Sweden.
Banning & Seybold beater at Korsnäs Ab's Research Laboratory Gävle, Sweden.
Valley beater (orig. TAPPI) at Centrallaboratorium Ab, Helsingfors, Finland.
Lampén mill at Centrallaboratorium Ab, Helsingfors, Finland.
Noble & Wood cycle beater at Centrallaboratorium Ab, Helsingfors, Finland.

The Aylesford Laboratory Beater, Fig. 1, operates as a small vertical jordan mill through which the pulp suspension can be recirculated. The apparatus, originally intended for investigation of the beating process, but now also used in routine testing of pulp, was designed in 1934 at the Central Laboratory of Albert E. Reed & Co. in Aylesford, England. A detailed description of the apparatus is given by L. G. Cottrall and J. Gartshore (*1*, *2*). The laboratory model of the Aylesford beater was developed from the corresponding mill apparatus and is built as a precision instrument in which the rotational speed of the cone can be varied from 1300 to 2500 r.p.m. and where the clearance between the rotor bars and the shell bars can be set with great accuracy. The power load can be varied from 0.45 to 3.0 kw. The beating is normally performed at a consistency of 3% and by regulating the clearance between the bars the power load is kept constant during the beating, usually at 2.5 amp. for sulphites and 3.0

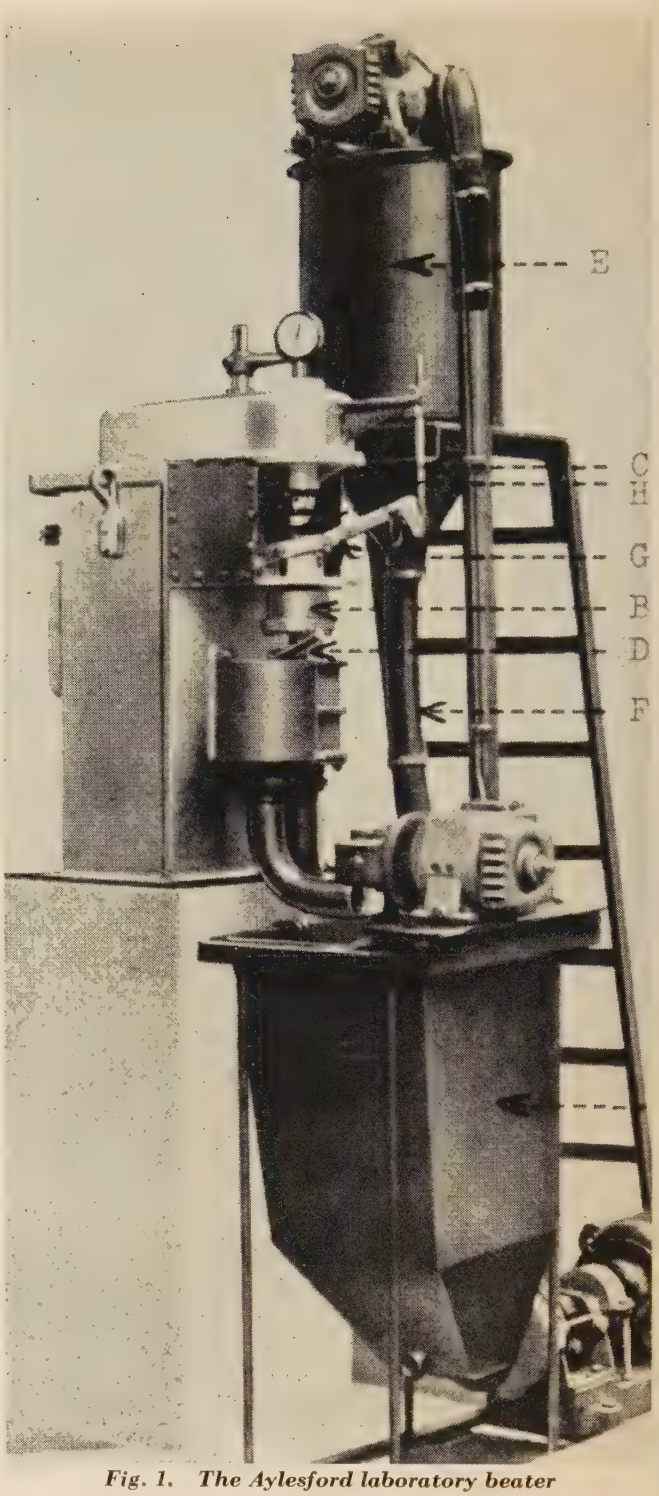
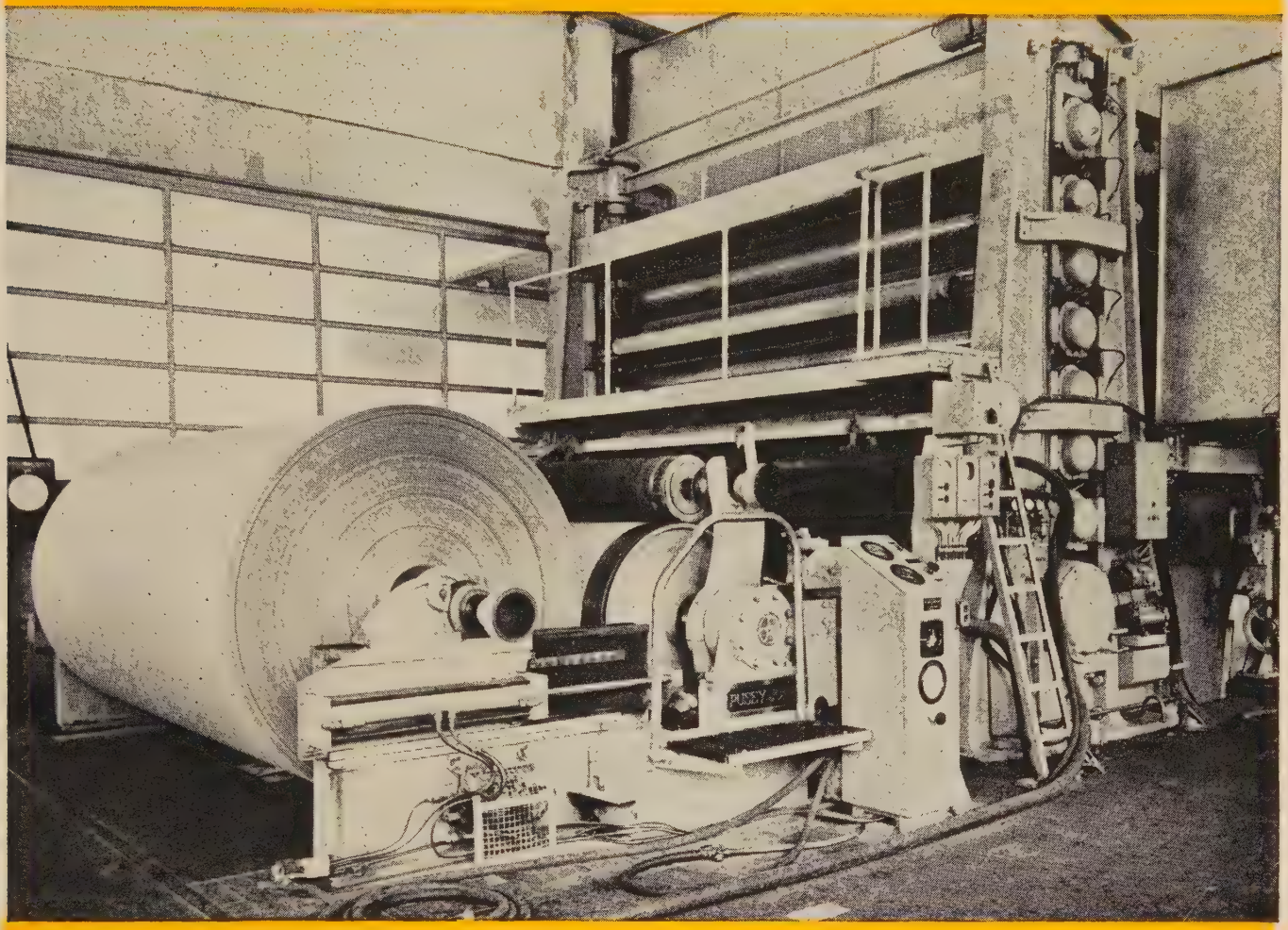


Fig. 1. The Aylesford laboratory beater

Puseyjones Improved Type Pope Reel installed in Italian Kraft paper mill. Reel has horizontal track air-loaded nip pressure, 36" diameter Reel drum, 64" maximum diameter paper roll.



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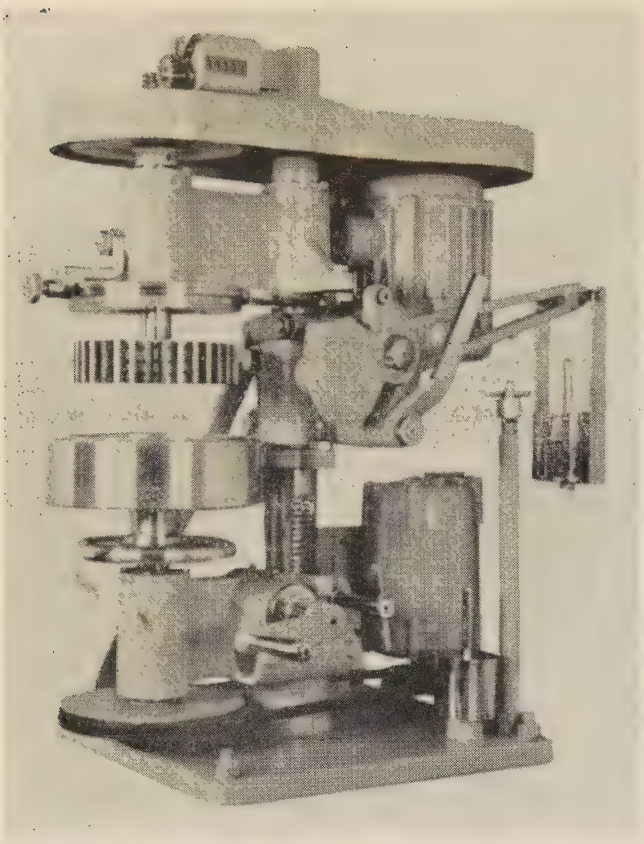

Fig. 2. The PFI mill

amp. for sulphates at a voltage of 440 v. In the design of the apparatus the aim has been to get an instrument which in operation gives strength values which, as far as possible in respect to their magnitude, simulate those obtained with the corresponding mill apparatus.

The PFI Mill, Fig. 2, operates as a bar hollander beater with a completely smooth bedplate. The apparatus was designed in 1947 at the Papirindustriens Forskninginstitutt in Oslo and a description has been given by E. Stephansen (*3*). The roll and the cylindrical casing, which also serves as the bedplate, are rotated in the same direction at different speeds. The pulp consistency and the beating pressure, can be varied within a large range. Moreover the distance between the roll bars and the bedplate can be set so as to allow the beating to be performed with direct contact as well as with a definite clearance between roll and bedplate.

The Lampén Mills in Oslo and Helsingfors were ordinary Lampén mills with a 10-kg. ball. The Lampén mill in Oslo was made by Svenska Apparat Ab, and the one in Helsingfors by the Warkaus mill of A. Ahlström Oy.

The Banning-Seybold laboratory beater in Korsnäs was an original beater made by Maschinenfabrik Banning & Seybold A. G., Düren, (Phl) in Germany. This type of beater, the so-called "Überwurfholländer." Fig. 3, is developed from the mill beater with the same name, which was described by H. Banning (*4*) in 1932. The bedplates of the beater are attached in two bundles to the vat at the side of the roll. The load is applied by loading a lever which presses the roll against the bedplates. As in the case of the Aylesford laboratory beater the aim in the design of the laboratory model has been to get strength values of the same order of magnitude as with a full scale beater of the same type.

The Banning Seybold Beater in Skönsmon was a modified B & S beater designed in 1945 by the research laboratory of the Svenska Cellulosa Ab. The loading arrangement, the bar material, and the profile of the roll bars differ in some way from the original B & S beater.

The Valley Beater in Korsnäs was a copy of the original Valley beater made in Sweden. The bedplate however, the most important part of the Valley beater, is not made in this model according to the original American description, i.e., without a threshold in front of the first bedplate bar and with wooden fillings between the bars. The beating in this beater is essentially different from that in an orthodox Valley beater.

The Valley Beaters in Helsingfors (the sulphites were beaten in one beater, the sulphates in another) were original American $1^1/_2$-lb. Niagara-type Valley beaters with controllable bedplate. The beating pressure is applied by means of weights on the bedplate lever arm. A detailed description of the beater is given in TAPPI Standard T 200 m-45 (*5*).

The Noble & Wood Cycle Beater in Helsingfors, Fig. 4, was an original American beater with bronze bars made by The Noble & Wood Machine Co., Hoosick Falls, N.Y. The beating pressure is set by loading the roll with a weight moving on a lever arm. The beater has been described previously by T. Ekstam (*6*) in connection with comparative beatings with this beater and the Valley beater and Lampén mill.

Beating Conditions

At a predetermined date for each pulp quality, the beating tests were performed simultaneously in all laboratories in order to avoid differences due to unequal storage time. Triplicate beatings were carried out in all beaters and for every beating an average sample was taken consisting of equal amounts of pulp from every single pulp piece. The beatings were made according to the usual methods of the respective labora-

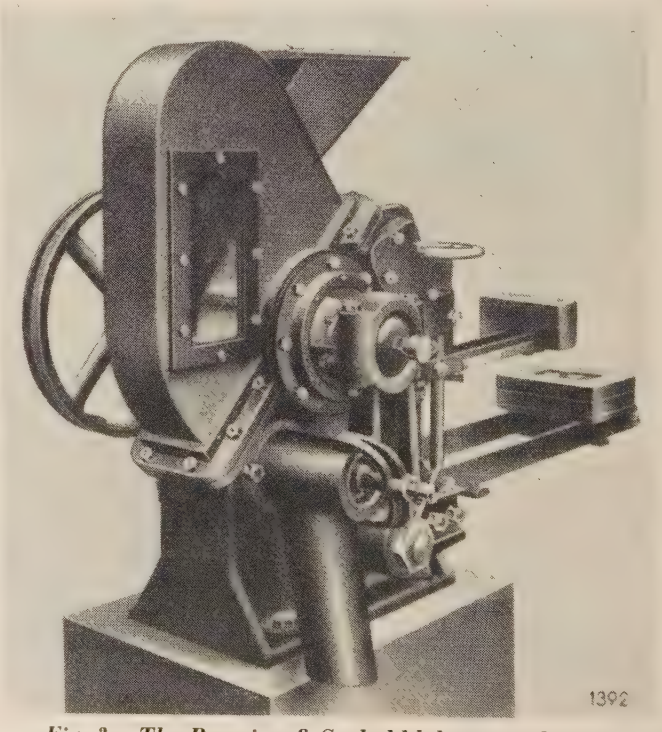

Fig. 3. The Banning & Seybold laboratory beater

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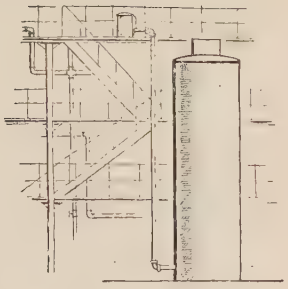

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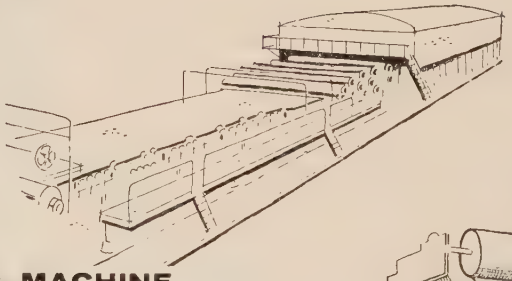

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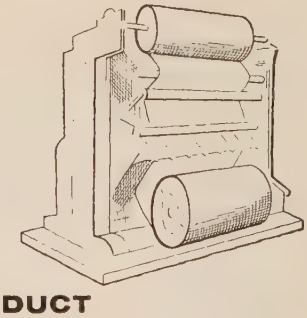

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Table I. The Beating Conditions in the Various Laboratories

Laboratory	*Reed*	*PFI, Oslo*		*S.C.A. Skönsmon*	*Korsnäs*		*C.L. Helsingfors*		
Beater	Aylesford	PFI mill	Lampén	B & S beater (S.C.A.)	Valley (Wennberg)	B & S beater (orig.)	Valley (TAPPI)	Lampén	N & W beater
Roll speed r.p.m.	1300	1500	300	400	ca. 550	400	ca. 500	250	490
Periph. speed of bars, m./min.	...	348 rel.	...	502	336	502	305	...	590
Beating pressure, kg./cm.	...	Soft 1.9 Strong 3.4	...	...	...	Si: 0.4 Sa: 0.5	Bsi: 0.2, 10 lb. Usi: 0.26, 13 lb. Sa: 0.3, 15 lb.	...	Si: 0.2 Sa: 0.5
Loading of the lever	...	...	Ball 10 kg.	Si: 0 kg. Sa: 2.5 kg.	Si: 4 kg. Sa: 15 kg.	...	...	Ball 10 kg.	...
Power load, amp.	Si: 2.5 Sa: 3.0	...	...	...	...	...	...	...	...
Charge of pulp (moisture-free) B.D., g.	1620	22.5	22.5	900	500	550	450	30	Ra 2800, 3500
Consistency in the beater, %	3.0	10.0	3.0	6.0	2.0	5.0	2.0	3.0	4.0, 5.0
Temperature	60–70°F.	20°C.	20°C.	20°C.	20°C.	20°C.	25°C.	20°C.	25°C.
pH water	7.0–7.9	6.5	6.5	7.0	7.0	7.0–7.3	7.0–7.4	7.0–7.4	5.8–7.6
Disintegrator I	Ay. beater	Brit. dis.	Brit. dis.	Holmens	Holmens	B & S beater	Valley beater	Wennberg	N & W beater
Consistency in disintegrator, %	3.00	1.00	1.00	3.00	2.00	5.00	2.00	0.3	4.0, 5.0
Time for disintegration, min.	12½	10	10	30	15	...	Si: 60 Sa: 90	Si: 5 Sa: 15	15
Disintegrator II	Brit. dis.	Brit. dis.	Brit. dis.	Munksund	...	...	...	Wennberg	...
Consistency in disintegrator, %	1.2	1.00	1.00	0.2	...	...	...	0.2	...
Time for disintegration, min.	12½	3	3	2	...	...	...	2	...

tories for the beating apparatus and pulp quality in question.

Wetness and Sheetmaking

Samples were taken from the beaters at approximate wetnesses 20, 40, 60, 75, and 80°S.-R. In the case of the PFI mill and the Lampén mill, from which samples cannot be taken during beating, a sample was beaten to each of the above-mentioned wetnesses. For each sample the wetness was determined with both the Schopper-Riegler and the Canadian Standard freeness testers. In Reed's laboratory no S.-R., apparatus was available and the wetness obtained was converted to S.-R., figures according to TAPPI (*7*). From the beaten sample 10 sheets were made according to the British Paper & Board Makers Association Standard Method (*8*) (TAPPI Standard T 205 m-47) (*9*)) and the number of sheets varied depending on the requirements of the individual method of each laboratory. All the test sheets were sent, well packed, to the Central laboratorium Ab in Helsingfors for strength testing. The sheets made according to the BPBMA's Standard method were tested according to the BPBMA's Standard method at 65% R.H. and the sheets made according to the laboratories' own methods were tested as prescribed in these methods. Tables I and II are a detailed comparison of the beating, sheetmaking, and testing conditions in the different laboratories.

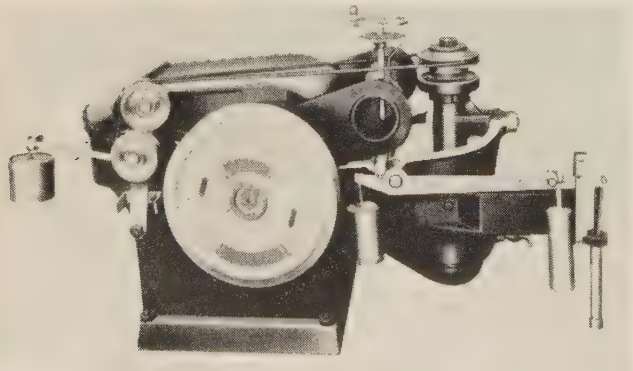

Fig. 4. The Noble & Wood cycle beater

From this comparison it is evident that the sheetmaking at Reed's differs from that of the original British method in that the basis weight of the sheets is 75 gram per sq. m. instead of 60 grams per sq. m., the sheets are pressed only once between blotters, for 3 min., instead of being pressed twice between blotters and gloss-plates, and the sheets are dried, detached from the blotters, at a temperature of 60°C. on a felt-covered drum instead of being dried at room temperature adhering to gloss-plates, where they are unable to shrink. The sheetmaking methods in Skönsmon and Helsingfors (*10*) are, except for the consistency and the suction height in the sheet mold, almost exactly the same. The sheets are dried on a drum between unshrinkable blotters and adhering to them. At Korsnäs the Swedish method (*11*) is applied except that the basis weight at Korsnäs is 60 grams per sq. m. instead of 100 grams per sq. m.

THE RESULTS OF THE INVESTIGATION

A. Comparison of the Testing Results of the Various Laboratories and the Grading of the Pulps (Laboratories' Own Method of Sheetmaking)

One of the main objects of the work was to investigate the correspondence between strength testing results obtained from the individual methods of the various laboratories. The pulp samples were therefore beaten in the beating apparatus of the particular laboratories according to their own current methods, and the strength properties of the sheets were determined according to the methods of the laboratories in question. The results of this part of the investigation have been compared in Tables III and IV and in Figs. 5 to 7, which give the strength values for the ten pulp qualities investigated obtained in the various laboratories and interpolated to 50°S.-R. Each value is the mean of three parallel beatings.

It should also be pointed out that the strength values reported for these pulp qualities should not be regarded as standard figures for these particular pulps, because the samples have been arbitrarily chosen in such a way that a large range of strength values could be obtained.

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Table II. The Sheetmaking and Testing Conditions in the Different Laboratories

Method	*Brit. Method*	*Reed*	*Oslo*	*Skönsmon*	*Korsnäs*	*C.L. Helsingfors*
Sheet machine	Brit.	Brit.	PFI	Sv. Cell. A.B.	Swed. Std.	C.L.
Size of the mold	Ø 158.8 sq. mm.	Ø 158.8 mm.	250 × 120 mm.	Ø 165 m.	Ø 215 mm.	165 × 165 mm.
Area of sheet, sq. cm.	200	200	300	214.5	364	272
Wire no.	150	150	150	100	80	100
Suction height, cm.	80	80	50	80	100	150
Dilution in the mold, g./l.	0.17	0.21	0.175	0.17	0.13	0.375
Couching	Blotters	Blotters	Blotters	Blotters	Blotters	Blotters
Sheet press	Brit.	Brit.	Eureka	Wennberg	Wennberg	Wennberg
Pressure	p.s.i. I 50 II 50	50 p.s.i.	kg./sq. cm. I 2.5 II 7.7	5 kg./sq. cm.	kg./sq. cm. I 1 II 15	5.4 kg./sq. cm.
Time of pressing, min.	5	3	3	7	1/2	5
Method of pressing	2 Glossplates & blotters	Blotters	3 Glossplates & blotters	Blotters	1 Glossplates & blotters	Blotters
Drying	Air drying	Felt cover cyl.	Cylinder	Cylinder	Cylinder	Cylinder
Method of drying	On glossplates	Without glossplates & blotters	On glossplates	Between blotters	On glossplates	Between blotters
Temperature, °C.	20	60	50	65	60	65
Drying time	4 hr.	25 min.	30 min.	45 min.	30 min.	2 hr.
Testing of the sheets						
Basis weight, moisture-free, g./sq. m.	60	75	70	60	60	66.7
Number of sheets	6	6	4	6	2	5
Length of the tensile strip, mm.	100	100	50	50	50	100
Bursting tester	Mullen	Dalén	Dalén	Mullen	Mullen	Mullen
Tearing tester	Marx-Elm.	Marx-Elm.	Orig. Elm.	Marx-Elm.	Orig. Elm.	Marx-Elm.
Base for calculation	moisture-free	moisture-free	65 R.H.	65 R.H.	65 R.H.	65 R.H.

the figures shown in Table A are taken from the curves derived from the average figures shown in Tables III and IV.

The pulps, krafts, sulphites, and bleached sulphites, are placed in the order of magnitude of burst factor, taking that obtained from the extra strong unbleached sulphite (77.3) by the Helsingfors Lampén as 100%. The other burst factors are calculated as a percentage of this figure in order to simplify this comparison.

For breaking length and tear factor, the same order of pulps and beaters as that for burst factor is adopted. The figures are shown in Tables B and C.

As a basis of comparison the Schopper-Riegler values have been chosen.

The Canadian freeness figures, which were also determined in the investigation, are not in all cases suitable as a basis of comparison, since the holes in the gridplate of the tester are so coarse that well-beaten soft sulphites and hardwood pass the gridplate and an erroneous picture of the drainage properties of the pulps is obtained.

The different institutes usually report their strength

Table III. Strength Properties of Bleached Sulphites at 50°S.-R. based on the Different Laboratories' Own Method of Sheetmaking

Pulp qualities and beaters	*Beating time*	*Wetness, S.-R.*	*Freeness, Canadian std., ml.*	*Break L, m.*	*Burst F, Mu*	*Burst F, Da*	*Tear F*	*Fold, Sch.*	*Str., %*	*Vol. w., kg./dm.³*	*Opacity Scatt. coeff.*	*Opacity C-R*	*Porosity B-U, sec.*	*Porosity G-H, sec.*	*Porosity Sch., cm.³/min*
Extra strong—bleached sulphite															
Aylesford beater, Reed	29 min.	50.0	216	5900	52.5	49.0	192	1625	7.5	0.667	295	0.75	138	1537	12
B & S beater, Skönsmon	21 min.	50.0	176	6335	50.8	...	88	1115	6.1	0.678	230	0.76	26	165	54
PFI-Mölle, Oslo	92 sec.	50.0	264	8465	60.4	54.2	70	2185	5.0	0.890	204	0.66	140	1043	12
Lampén mill, Oslo	79 min.	50.0	258	9565	65.1	60.2	62	2185	4.5	0.950	153	0.62	186	1423	9
Valley beater, Helsingfors	59 min.	50.0	189	8050	53.9	...	160	2250	3.8	0.756	227	0.71	113	...	...
Lampén mill, Helsingfors	61 min.	50.0	176	9495	64.3	...	129	2300	4.1	0.865	144	0.53	157	...	...
N & W beater, Helsingfors	29 min.	50.0	179	7175	51.1	...	158	1800	4.0	0.755	237	0.70	106	...	...
Valley beater, Korsnäs	55 min.	50.0	...	8850	60.3	55.6	72	2165	4.4	0.863	169	0.64	227	1816	17
B & S beater, Korsnäs	12 min.	50.0	...	6950	51.9	50.8	74	1350	5.1	0.836	190	0.69	129	3000	8
Strong—bleached sulphite															
Aylesford beater, Reed	29 min.	50.0	216	4150	36.0	33.8	170	240	6.1	0.621	425	0.79	60	140	36
B & S beater, Skönsmon	16 min.	50.0	232	4585	34.0	...	76	200	5.5	0.620	374	0.80	13	58	235
PFI-Mölle, Oslo	71 sec.	50.0	287	6485	43.7	40.9	69	920	4.7	0.809	266	0.72	75	142	33
Lampén mill, Oslo	61 min.	50.0	257	6800	42.4	39.5	62	615	4.2	0.898	216	0.68	108	199	22
Valley beater, Helsingfors	55 min.	50.0	190	6285	41.6	...	142	870	3.7	0.722	300	0.75	92	...	...
Lampén mill, Helsingfors	66 min.	50.0	158	7665	49.6	...	113	1190	3.7	0.889	159	0.60	299	...	...
N & W beater, Helsingfors	27 min.	50.0	199	5365	35.4	...	145	550	3.9	0.700	316	0.76	35	...	...
Valley beater, Korsnäs	52 min.	50.0	189	6645	40.9	38.7	60	815	3.5	0.861	226	0.71	166	306	26
B & S beater, Korsnäs	11 min.	50.0	161	5600	37.5	37.0	71	535	4.6	0.822	257	0.73	34	125	73
Soft—bleached sulphite															
Aylesford beater, Reed	30 min.	50.0	217	3500	30.0	28.9	136	58	6.4	0.611	470	0.82	43	238	46
B & S beater, Skönsmon	12 min.	50.0	215	3735	26.7	...	58	35	5.5	0.617	386	0.82	9	50	297
PFI-Mölle, Oslo	81 sec.	50.0	262	5285	38.9	36.7	59	215	4.4	0.801	280	0.72	47	293	41
Lampén mill, Oslo	130 min.	50.0	233	5355	30.4	30.4	40	75	3.6	0.888	240	0.60	57	390	35
Valley beater, Helsingfors	38 min.	50.0	208	5635	34.7	...	114	160	3.9	0.710	327	0.75	30	...	...
Lampén mill, Helsingfors	69 min.	50.0	172	6535	35.6	...	82	200	3.6	0.871	194	0.61	207	...	...
N & W beater, Helsingfors	19 min.	50.0	184	4730	29.4	...	109	85	3.7	0.690	337	0.76	28	...	...
Valley beater, Korsnäs	27 min.	50.0	197	5750	33.0	31.5	48	115	3.0	0.840	231	0.72	124	1161	67
B & S beater, Korsnäs	14 min.	50.0	216	4925	34.0	32.2	60	135	4.0	0.780	285	0.75	24	122	98
Aspen—bleached sulphite															
Aylesford beater, Reed	50 min.	50.0	264	3600	23.0	23.7	88	15	3.9	0.632	500	0.81	42	245	41
B & S beater, Skönsmon	10 min.	50.0	180	3040	17.7	...	35	5	3.8	0.611	439	0.83	5	25	330
PFI-Mölle, Oslo	87 sec.	50.0	236	4425	27.4	26.7	50	25	4.4	0.832	373	0.78	32	133	53
Lampén beater, Oslo	...	50.0	...	...	...	...	...	...	...	...	...	...	...	...	...
Valley beater, Helsingfors	74 min.	50.0	171	5300	29.3	...	87	75	3.2	0.754	372	0.79	69	...	...
Lampen mill, Helsingfors	137 min.	50.0	268	6150	33.9	...	81	115	3.1	0.853	276	0.70	190	...	...
N & W beater, Helsingfors	51 min.	50.0	181	4415	24.4	...	84	30	3.2	0.708	421	0.81	26	...	...
Valley beater, Korsnäs	101 min.	50.0	187	4340	21.1	21.8	40	15	3.1	1.022	295	0.84	57	312	43
B & S beater, Korsnäs	13 min.	50.0	180	4360	23.9	23.9	54	25	2.9	0.836	347	0.81	22	133	74
Rayon—bleached sulphite															
Aylesford beater, Reed	32 min.	50.0	212	3000	24.0	23.2	151	30	5.3	0.580	699	0.84	13	84	92
B & S beater, Skönsmon	15 min.	50.0	193	3135	25.7	...	79	65	5.2	0.595	438	0.84	9	49	333
PFI-Mölle, Oslo	119 sec.	50.0	290	5185	34.9	32.1	76	250	4.5	0.792	332	0.80	19	100	127
Lampén mill, Oslo	110 min.	50.0	245	4230	21.3	20.8	58	20	3.1	0.844	376	0.80	12	76	132
Valley beater, Helsingfors	56 min.	50.0	187	5065	33.0	...	141	285	3.4	0.707	443	0.81	26	...	...
Lampén mill, Helsingfors	102 min.	50.0	149	4530	22.4	...	89	25	2.7	0.799	351	0.76	37	...	...
N & W beater, Helsingfors	25 min.	50.0	189	4500	29.5	...	145	125	3.7	0.649	466	0.81	13	...	...
Valley beater, Korsnäs	53 min.	50.0	183	5100	33.8	33.2	63	150	4.4	0.785	307	0.76	17	115	108
B & S beater, Korsnäs	9 min.	50.0	185	4415	27.6	29.9	82	95	5.2	0.742	353	0.80	13	81	207

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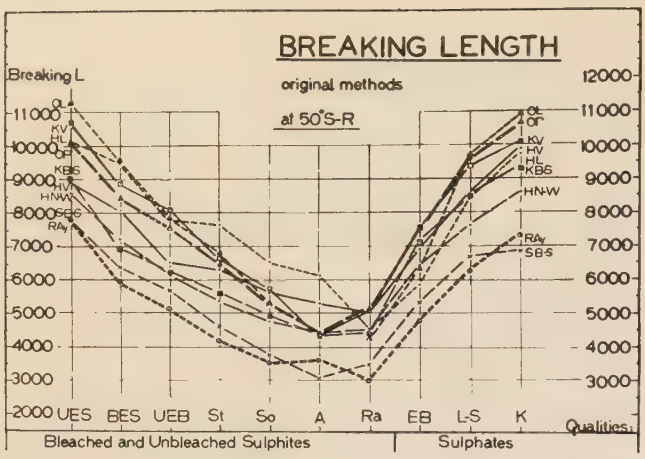


Fig. 5. The breaking length at 50°S.-R. for the different pulp qualities, with the various beaters; sheets made and tested according to the original methods of the different laboratories

figures at different wetness levels, e.g., 45°S.-R. in Sweden, 300° Canadian Standard freeness (equivalent to 40°S.-R.) in Britian, and 50°S.-R. in Finland. It would therefore be correct to compare the beating results at all these wetness levels. This would, however, increase the number of tables and figures considerably and, since the strength curves for a given pulp in the various beaters in this limited wetness range are nearly parallel, the strength values at 50°S.-R. (which are used as a basis in Helsingfors) give a fairly good idea of the strength levels obtained in the various laboratories.

Beaters:

HL = Lampén mill in Helsingfors
HV = Valley beater in Helsingfors
HN–W = Noble & Wood beater in Helsingfors
RAy = Aylesford beater by Reeds in England
KV = Valley beater in Korsnäs
KB–S = Banning Seybold beater in Korsnäs
OP = PFI-mill in Oslo
OL = Lampén mill in Oslo
SB–S = Banning & Seybold beater in Skönsmon

Pulp qualities:

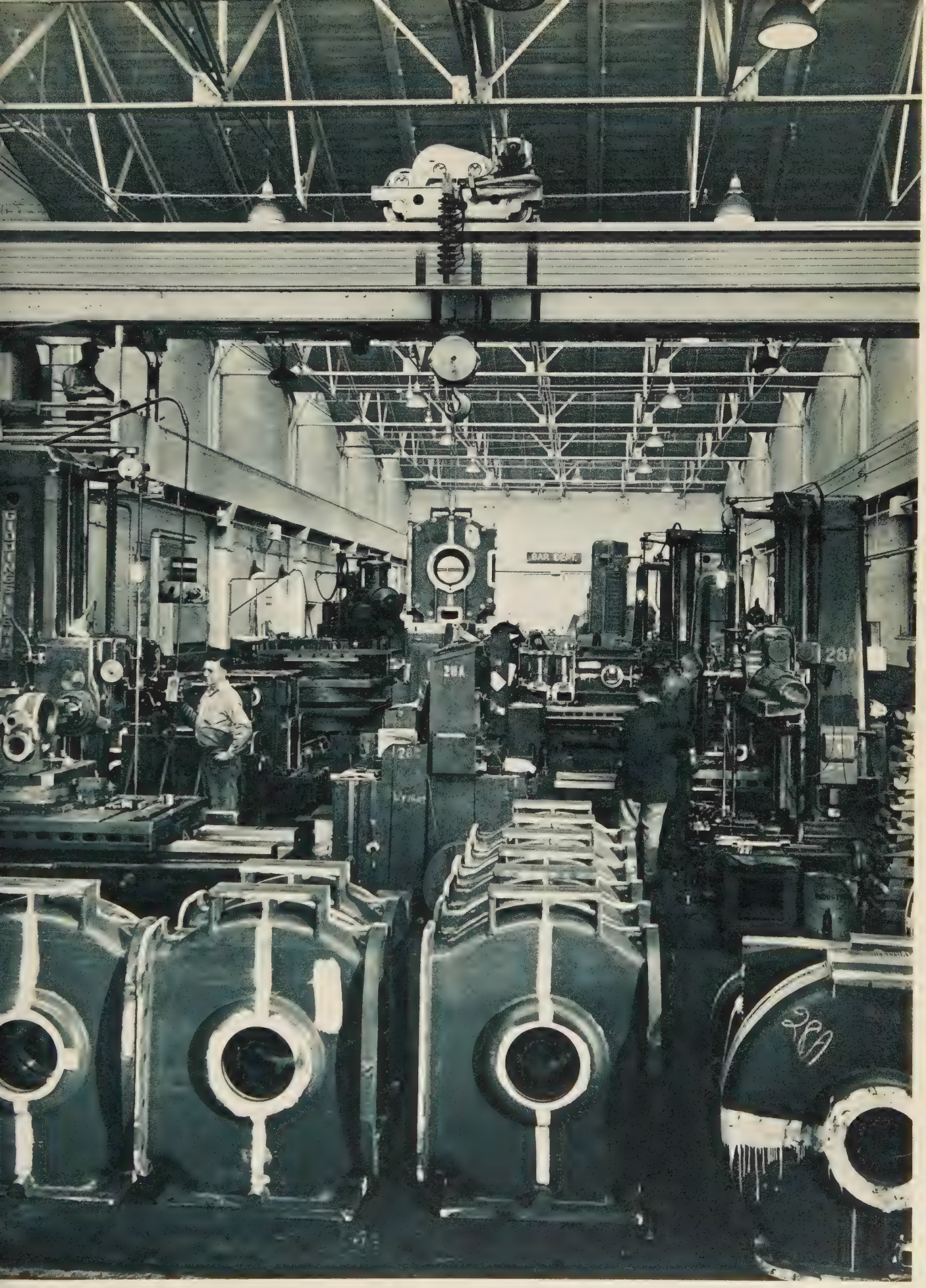
UES = unbl. sulphite pulp, Extra strong
UEB = unbl. sulphite pulp, Easy bleaching
BES = bleached sulphite pulp, Extra strong
St = bleached sulphite pulp, Strong
So = bleached sulphite pulp, Soft
A = bleached sulphite pulp, Aspen
Ra = bleached sulphite pulp, Rayon
EB = unbl. sulphate pulp, Easy bleaching
LS = unbl. sulphate pulp, Light & strong
K = unbl. sulphate pulp, Kraft

Level of Results. As is expected, the level of results between the different laboratories varies and in extreme cases there is a difference of up to 30% between the highest and the lowest figures shown for burst factor and breaking length for a particular pulp (Tables A and B).

The difference in level can be attributed to the type of beating and to the method of sheetmaking. Later in

Table IV. Strength Properties of Unbleached Sulphites and Sulphates at 50°S.-R. Based on the Different Laboratories' Own Methods of Sheetmaking

Pulp qualities and beaters	*Beating time*	*Wetness, S.R.*	*Freeness, Canadian std., ml.*	*Break L, m.*	*Burst F, Mu*	*Burst F, Da*	*Tear F*	*Fold, Sch.*	*Str., %*	*Vol. w., kg./dm.³*	*Opacity Scatt. coeff.*	*Opacity C-R*	*Porosity B-U, sec.*	*Porosity G-H, sec.*	*Porosity Sch., cm.³/min.*
Extra strong—unbleached sulphite															
Aylesford beater, Reed	25 min.	50.0	219	7,750	72.0	64.4	178	4650	8.3	0.639	173	0.69	400	2530	9
B & S beater, Skönsmon	19 min.	50.0	241	7,750	62.7	...	83	2150	5.6	0.682	215	0.74	22	95	131
PFI-Mölle, Oslo	86 sec.	50.0	236	10,085	71.0	63.4	66	2265	5.4	0.818	153	0.65	207	2540	14
Lampén mill, Oslo	82 min.	50.0	249	11,285	79.5	68.4	59	3300	5.2	0.887	118	0.58	188	1800	11
Valley beater, Helsingfors	36 min.	50.0	229	8,910	63.9	...	150	2980	4.2	0.766	169	0.68	84	...	...
Lampén mill, Helsingfors	56 min.	50.0	218	10,175	77.3	...	125	3365	5.2	0.812	112	0.58	100	...	...
N & W beater, Helsingfors	34 min.	50.0	227	8,550	63.6	...	151	2765	4.5	0.755	179	0.69	82	...	...
Valley beater, Korsnäs	37 min.	50.0	...	10,675	65.7	59.7	69	2700	4.5	0.802	136	0.63	270	2000	19
B & S beater, Korsnäs	8 min.	50.0	...	9,020	58.5	55.9	73	2950	4.7	0.797	133	0.65	350	1900	30
Easy bleaching—unbleached sulphite															
Aylesford beater, Reed	38 min.	50.0	217	5,100	44.0	41.0	191	1200	6.9	0.619	373	0.84	142	723	20
B & S Beater, Skönsmon	26 min.	50.0	205	5,665	45.6	...	91	1125	5.9	0.672	310	0.82	24	150	70
PFI-Mölle, Oslo	120 sec.	50.0	198	7,565	55.5	50.7	74	2285	5.6	0.843	241	0.73	211	1610	13
Lampén mill, Oslo	126 min.	50.0	226	7,850	52.2	48.4	74	1465	5.7	0.901	199	0.69	296	2360	15
Valley beater, Helsingfors	54 min.	50.0	194	6,500	47.9	...	169	1800	4.4	0.737	250	0.75	70	...	...
Lampén mill, Helsingfors	61 min.	50.0	182	7,795	55.1	...	138	2215	4.9	0.851	158	0.63	92	...	...
N & W beater, Helsingfors	44 min.	50.0	220	6,115	45.0	...	177	1640	4.7	0.718	281	0.78	47	...	...
Valley beater, Korsnäs	38 min.	50.0	...	8,115	48.9	44.2	83	1965	4.2	0.830	210	0.73	257	1620	11
B & S beater, Korsnäs	7 min.	50.0	...	6,245	43.1	41.3	78	1100	5.1	0.810	234	0.78	221	1595	19
Kraft—unbleached sulphate															
Aylesford beater, Reed	51 min.	50.0	218	7,330	73.8	65.7	281	4960	10.7	0.632	237	0.95	133	718	17
B & S beater, Skönsmon	46 min.	50.0	275	6,885	55.6	...	112	1400	6.0	0.607	278	0.93	19	86	261
PFI-Mölle, Oslo	311 sec.	50.0	223	10,715	83.2	72.4	102	3345	6.1	0.772	192	0.88	85	485	26
Lampén-mill, Oslo	153 min.	50.0	231	10,990	79.9	71.6	97	2600	5.2	0.796	169	0.90	76	414	36
Valley beater, Helsingors	101 min.	50.0	231	9,950	80.5	...	240	4470	4.4	0.681	241	0.92	55	...	...
Lampén mill, Helsingfors	132 min.	50.0	242	9,835	75.5	...	211	4585	4.6	0.696	196	0.90	42	...	...
N & W beater, Helsingfors	47 min.	50.0	219	8,600	66.8	...	225	3600	5.1	0.665	246	0.93	35	...	...
Valley beater, Korsnäs	66 min.	50.0	...	10,140	72.4	66.1	94	2035	4.7	0.758	181	0.90	63	537	38
B & S beater, Korsnäs	25 min.	50.0	...	9,375	72.5	64.5	99	3920	5.3	0.769	187	0.89	32	163	94
Light and strong—unbleached sulphate															
Aylesford beater, Reed	43 min.	50.0	217	6,275	60.5	55.6	317	2635	9.7	0.623	302	0.94	73	435	27
B & S beater, Skönsmon	37 min.	50.0	230	6,685	56.2	...	129	2335	7.0	0.637	261	0.93	11	84	267
PFI-Mölle, Oslo	332 sec.	50.0	244	9,675	73.2	65.6	110	3065	5.8	0.747	207	0.89	60	337	43
Lampén mill, Oslo	120 min.	50.0	223	9,745	67.5	61.2	91	2305	5.3	0.808	179	0.88	55	300	34
Valley beater, Helsinfors	75 min.	50.0	254	8,585	69.8	...	261	3615	4.6	0.665	229	0.90	47	...	...
Lampén mill, Helsingfors	104 min.	50.0	245	8,460	62.5	...	205	2550	4.2	0.738	204	0.89	39	...	...
N & W beater, Helsingfors	42 min.	50.0	228	7,625	60.0	...	243	2885	5.4	0.660	244	0.93	26	...	...
Valley beater, Korsnäs	65 min.	50.0	...	9,415	67.0	60.5	99	2565	4.9	0.758	189	0.87	132	1250	36
B & S beater, Korsnäs	39 min.	50.0	...	8,550	63.7	59.4	127	3190	6.1	0.739	196	0.92	9	49	384
Easy bleaching—unbleached sulphate															
Aylesford beater, Reed	34 min.	50.0	217	4,775	42.8	40.8	234	600	8.6	0.598	359	0.96	34	157	56
B & S beater, Skönsmon	18 min.	50.0	264	5,310	41.4	...	108	215	6.1	0.588	331	0.94	5	27	638
PFI-Mölle, Oslo	170 sec.	50.0	248	7,565	51.7	48.1	91	1465	4.8	0.761	269	0.92	38	192	78
Lampén mill, Oslo	88 min.	50.0	224	6,360	41.3	38.0	72	365	3.7	0.806	242	0.92	29	157	90
Valley beater, Helsingfors	42 min.	50.0	230	6,925	49.2	...	198	1050	4.3	0.656	372	0.95	23	...	...
Lampén mill, Helsingfors	51 min.	50.0	206	5,885	34.4	...	140	220	3.8	0.737	350	0.95	22	...	...
N & W beater, Helsingfors	26 min.	50.0	226	6,450	45.4	...	195	1340	4.8	0.655	372	0.95	23	...	...
Valley beater, Korsnäs	48 min.	50.0	...	7,585	51.5	46.5	78	950	4.7	0.791	227	0.89	128	933	51
B & S beater, Korsnäs	19 min.	50.0	...	7,150	53.0	49.2	104	1235	5.7	0.740	239	0.91	45	231	57



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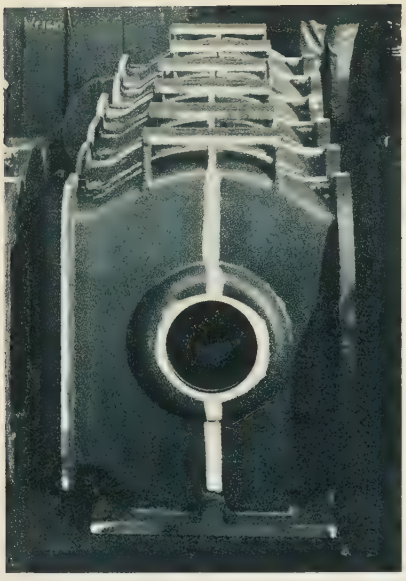

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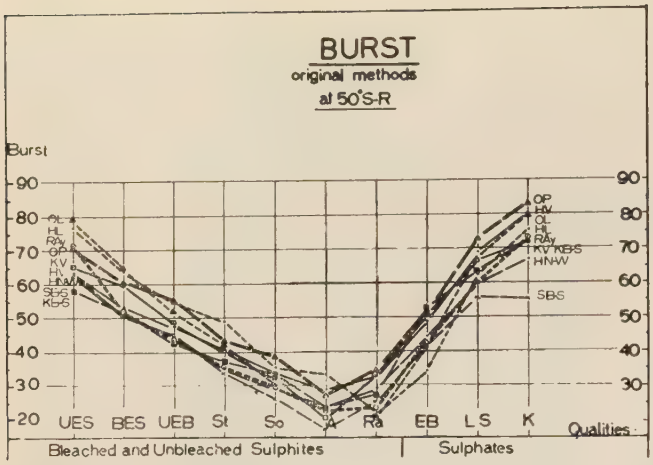

Fig. 6. The burst factor, at 50°S.-R. for the different pulp qualities, with the various beaters; sheets made and tested according to the original methods of the different laboratories

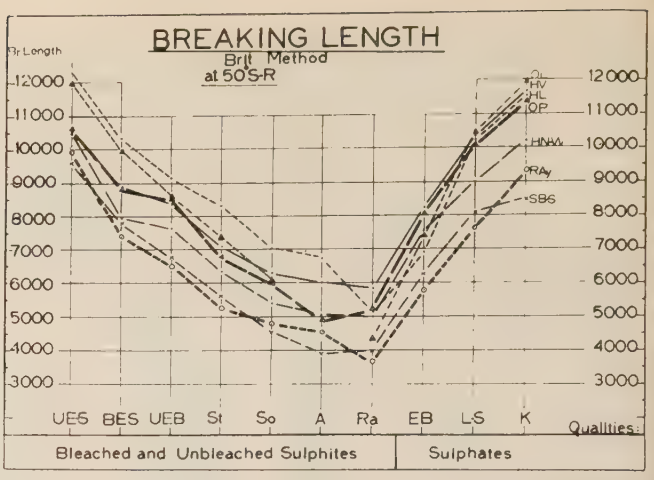

Fig. 8. The breaking length at 50°S.-R. for the different qualities with the various beaters; sheets made and tested according to the British method (B.P. & B.M.A's Method)

the report, when the results are discussed where only one method of sheetmaking is employed, namely the British Standard method of the BPBMA, the difference in level is as great, thus showing that the type of beating mostly controls the level of results.

There is no general scheme into which the level of a particular pulp falls when treated by a particular beater. There is a tendency for the Lampén mill to give the highest figures with the strongest pulps and the lowest figures with very soft pulps.

Grading. As shown by Table A and Fig. 6 the grading of the *burst factor* in *each particular class of pulp* (sulphate, sulphite, or bleached sulphite) is, with few exceptions, the same for each type of beater.

Apart from the Skönsmon Banning-Seybold beater evaluating kraft and L & S sulphate on the same level, the main exception is that of the Lampén mills, where the classification of the weak pulps, aspen, bleached sulphite, and rayon is the reverse of that of the barred beaters.

When considering the ten pulps as a whole, the correlation between the beaters is not so good. For instance, while most of the beaters give figures for kraft equal to or higher than those for extra strong unbleached sulphite (in the case of the PFI, Helsingfors Valley, and Korsnäs Banning-Seybold they are much higher), the Skönsmon Banning-Seybold figure for kraft is definitely lower than for extra strong sulphite.

The *breaking length* values, shown in Table B and Fig. 5 fall in line with the burst factor values. Each beater in each particular class of pulp grades in the same way, the exception again being the Skönsmon Banning-Seybold, which evaluates kraft and L & S sulphate on the same level.

The *tearing strength* values Tables C and Fig. 7, are divided into two fairly well-restricted groups, with the Reed and Helsingfors values considerably higher than the others. This is not due to the beating conditions, but to the fact that the tearing strength at Reeds and in Helsingfors is calculated according to the original instructions for the Marx-Elmendorf apparatus, which means that the tearing value is twice as high as when the tearing strength is calculated according to the instructions for the Elmendorf apparatus employed by the other research institutes.

The strength curves for the various laboratories are fairly parallel for strong pulp qualities. With the exception of the weakest qualities it is possible to predict approximately the level, but not the exact figures of the strength values given by the various laboratories for a pulp quality on the basis of the testing results obtained

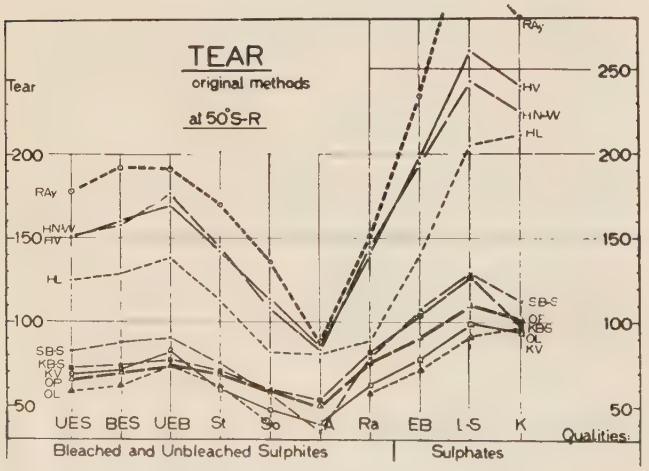

Fig. 7. The tear factor, at 50°S.-R. for the different pulp qualities, with the various beaters; sheets made and tested according to the original methods of the different laboratories

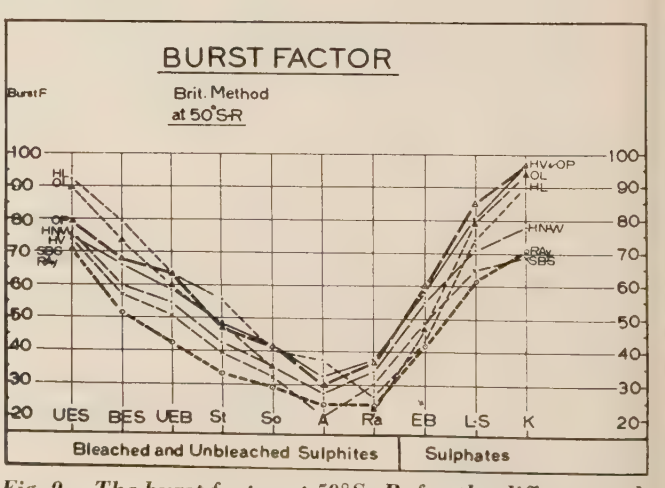

Fig. 9. The burst factor at 50°S.-R. for the different pulp qualities with the various beaters; sheets made and tested according to the British method

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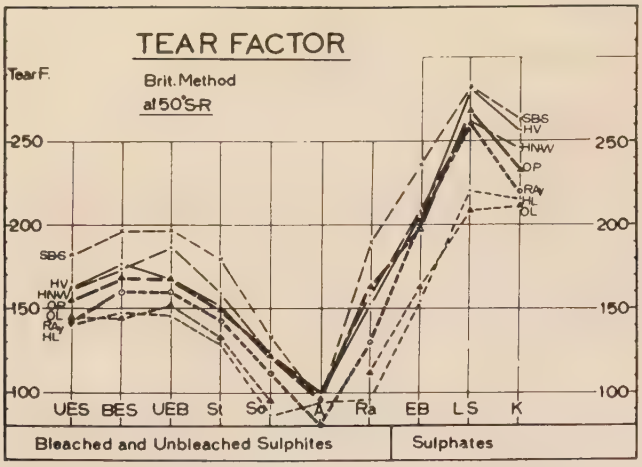

Fig. 10. The tear factor at 50°S.-R. for the different pulp qualities with the various beaters; sheets made and tested according to the British method

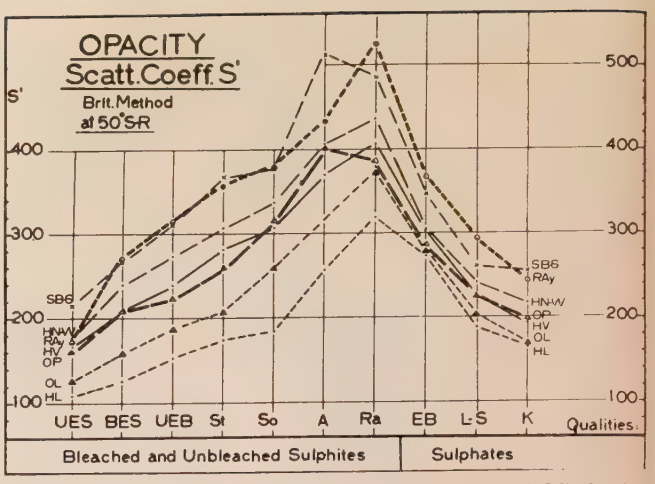

Fig. 12. The opacity, scattering coefficient at 50°S.-R. for the different pulp qualities with the various beaters; sheets made and tested according to the British method

in one laboratory. Incidentally, the research laboratory of the Svenska Cellulosa A.B. has now changed from the Banning-Seybold beater to the American Valley beater. There is now a fairly good correlation between the testing results from Skönsmon and the results obtained with the Valley beater in Helsingfors on account of the similar sheetmaking and beating procedure. The calculation of the tearing factor, however, is different, and the values of Skönsmon are therefore half the values of Helsingfors.

B. The Performance of the Different Beating Apparatus (Judged on the Results from the British Method of Sheetmaking)

The beating results obtained according to the laboratories own methods showed that the differences between the strength values for a given pulp quality determined according to different methods are considerable. The question whether these differences for a given pulp are caused by the beating apparatus or the sheetmaking method is answered by an examination of the results from the beating tests, which were performed using a single sheetmaking procedure, i.e., the British sheetmaking and testing method. Since the equipment of the laboratory in Korsnäs did not include the British apparatus the manner of beating of their Valley beater and their B & S beater cannot be directly compared with that of the other beaters.

The results from these beatings, in which the sheetmaking was performed according to the BPBMA's method, have been compared in Tables V to XIV in which the complete beatings of all ten pulp qualities beaten in the beaters of Reed's laboratory and the laboratories in Oslo, Skönsmon, and Helsingfors have been tabulated. Each value is the mean of three parallel beatings. In these tables the beating time wetness, S.-R. and Canadian freeness are given, together with the usual strength values, the tensile and burst factor both with the Mullen and with the Dalén apparatus, the tearing factor with Marx-Elmendorf and folding endurance with the Schopper instrument. The stretch, apparent specific gravity, opacity as scattering coefficient and contrast ratio, and porosity measured with the Bekk-Ullstein, Gurley-Hill, and Schopper instruments are also given. In Figs. 8 to 13 the strength properties of the pulps as obtained with the different beaters and independent of differences in the sheetmaking conditions are compared.

A cursory comparison of these curves with those obtained for sheets made in accordance with the individual methods of the different laboratories, Figs. 5 to 7,

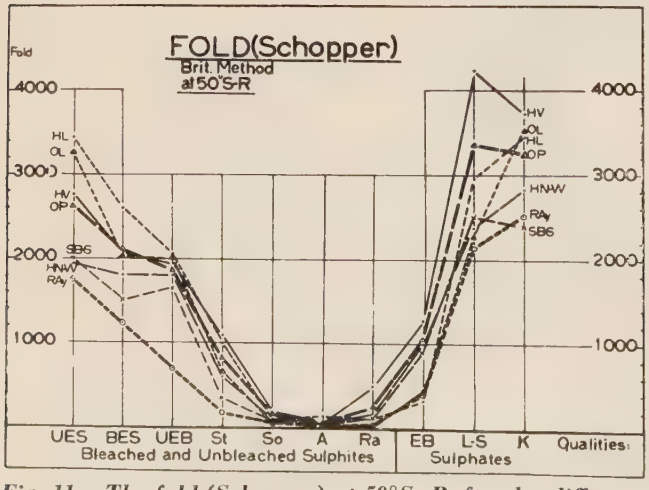

Fig. 11. The fold (Schopper) at 50°S.-R. for the different pulp qualities with the various beaters; sheets made and tested according to the British method

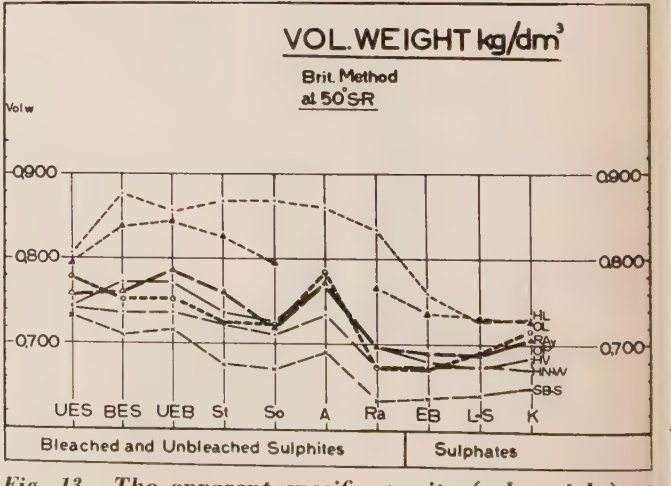

Fig. 13. The apparent specific gravity (vol. weight) at 50°S.-R. for the different pulp qualities with the various beaters; sheets made and tested according to the British method

BECCO Processes

Ask for facts on BECCO's 2-stage hypochlorite-peroxide bleaching of sulfites and semichemicals

The 2-stage hypochlorite-peroxide process produces a high yield of pulp of fine quality with exceptional brightness and stability. Investment for equipment is low and chemical cost is moderate.

You can bleach many sulfite pulps to brightness levels of 85; some neutral sulfite semichemical pulps to 80. The process also has important values for the bleaching of agricultural residue pulps.

A moderate or high-density peroxide stage gives you high bleaching efficiency in terms of brightness gain per chemical dollar.

Ask to see Becco technical consultants or write for Bulletin D-14 giving complete description and schematics of process and equipment, tabulated bleaching data on many pulp types, and comparisons on both moderate and high-density bleaching by the Becco 2-stage hypochlorite-peroxide bleaching process.

Other Becco paper industry processes are described in the following bulletins: D-1 Becco Methods for Soda Pulp Bleaching, D-2 Becco Peroxide Bleaching Methods for Sulfite Pulps, D-3 Becco Procedures for Bleaching Kraft Pulps, D-4 Data on Flax Pulp Bleaching, D-5 Becco Peroxide Bleaching Methods for Semichemical Pulps, D-7 Becco Pulp Bleaching with Mixed Peroxides, D-8 Becco Pulp Dryer Steep Bleaching, D-10 Pretreatments for Groundwood Pulps, D-11 Becco Peracetic Acid 40% applications in Pulp and Paper Mills, D-12 Starch Solubilization with Becco Potassium Persulfate, D-13 Bleaching of Groundwood Pulp with Hydrogen Peroxide. Write for complete bulletin list and any of the above you desire.

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Table A. Burst Factor (Mullen) at 50°S.-R. Based on the Different Laboratories' Own Method of Sheetmaking

Beater	Extra strong unbleached sulphite	Kraft	Extra strong bleached sulphite	L & S sulphite	E.B. sulphite	Strong bleached sulphite	Soft bleached sulphite	E.B. sulphate	Bleached aspen	Rayon
Helsingfors Lampén	77.3 (100%)	75.5 (98%)	64.3 (83%)	62.5 (81%)	55.1 (71%)	49.6 (64%)	35.6 (46%)	34.4 (45%)	33.9 (44%)	22.4 (29%)
Oslo Lampén	79.5 (103%)	89.9 (103%)	65.1 (84%)	67.5 (87%)	52.2 (68%)	42.4 (55%)	30.4 (39%)	41.3 (53%)	...	21.3 (28%)
Oslo PFI	71.0 (92%)	83.2 (108%)	60.4 (78%)	73.2 (95%)	55.5 (72%)	43.7 (57%)	38.9 (50%)	51.7 (56%)	27.4 (35%)	34.9 (45%)
Korsnäs Valley	65.7 (85%)	72.4 (94%)	60.3 (78%)	67.0 (87%)	48.9 (63%)	40.9 (53%)	33.0 (43%)	51.5 (67%)	21.1 (27%)	33.8 (44%)
Skönsmon B & S	62.7 (81%)	55.6 (72%)	50.8 (66%)	56.2 (73%)	45.6 (59%)	34.0 (44%)	26.7 (35%)	41.4 (54%)	17.7 (23%)	25.7 (33%)
Helsingfors Valley	63.9 (83%)	80.5 (104%)	53.9 (70%)	69.8 (90%)	47.9 (62%)	41.6 (54%)	34.7 (45%)	49.2 (64%)	29.3 (38%)	33.0 (43%)
Helsingsfors N & W	63.6 (82%)	66.8 (86%)	51.1 (66%)	60.0 (78%)	45.0 (58%)	35.4 (46%)	29.4 (38%)	45.4 (59%)	24.4 (32%)	29.5 (38%)
Aylesford	72.0 (93%)	73.8 (95%)	52.5 (68%)	60.5 (78%)	44.0 (57%)	36.0 (47%)	30.0 (39%)	42.8 (55%)	23.0 (30%)	24.0 (31%)
Korsnäs B & S	58.5 (76%)	72.5 (94%)	51.9 (67%)	63.7 (82%)	43.1 (56%)	37.5 (49%)	34.0 (44%)	53.0 (69%)	23.9 (31%)	27.6 (36%)

Table B. Breaking Length at 50°S.-R. Based on the Different Laboratories' Own Method of Sheetmaking

Beater	Extra strong unbleached sulphite	Kraft	Extra strong bleached sulphite	L & S sulphite	E.B. sulphite	Strong bleached sulphite	Soft bleached sulphite	E.B. sulphate	Bleached aspen	Rayon
Helsingfors Lampén	10,175 (100%)	9,835 (97%)	9495 (93%)	8460 (83%)	7795 (77%)	7665 (75%)	6535 (64%)	5885 (58%)	6150 (60%)	4530 (45%)
Oslo Lampén	11,285 (111%)	10,990 (108%)	9565 (94%)	9745 (96%)	7850 (77%)	6800 (67%)	5355 (53%)	6360 (63%)	...	4280 (42%)
Oslo PFI	10,085 (99%)	10,715 (105%)	8465 (83%)	9675 (95%)	7565 (74%)	6485 (64%)	5285 (52%)	7565 (74%)	4425 (43%)	5185 (51%)
Korsnäs Valley	10,675 (105%)	10,140 (100%)	8850 (87%)	9415 (93%)	8115 (80%)	6645 (65%)	5750 (57%)	7585 (75%)	4340 (43%)	5100 (50%)
Skönsmon B & S	7,750 (76%)	6,885 (68%)	6335 (62%)	6685 (66%)	5665 (56%)	4585 (45%)	3735 (37%)	5310 (52%)	3040 (30%)	3485 (34%)
Helsingfors Valley	8,910 (88%)	9,950 (98%)	8050 (79%)	8585 (84%)	6500 (64%)	6285 (62%)	5635 (55%)	6925 (68%)	5300 (52%)	5065 (50%)
Helsingfors N & W	8,550 (84%)	8,600 (85%)	7175 (71%)	7625 (75%)	6115 (60%)	5365 (53%)	4730 (46%)	6450 (63%)	4415 (43%)	4500 (44%)
Aylesford	7,750 (76%)	7,330 (72%)	5900 (58%)	6275 (62%)	5100 (50%)	4150 (41%)	3500 (34%)	4775 (47%)	3600 (35%)	3000 (29%)
Korsnäs B & S	9,020 (89%)	9,375 (92%)	6950 (68%)	8550 (84%)	6245 (61%)	5600 (55%)	4925 (48%)	7150 (70%)	4360 (43%)	4415 (43%)

Table C. Tear Factor at 50°S.-R. Based on the Different Laboratories' Own Method of Sheetmaking

Beater	Extra strong unbleached sulphite	Kraft	Extra strong bleached sulphite	L & S sulphite	E.B. sulphite	Strong bleached sulphite	Soft bleached sulphite	E.B. sulphate	Bleached aspen	Rayon
Helsingfors Lampén	125 (100%)	211 (169%)	129 (103%)	205 (164%)	138 (110%)	113 (90%)	82 (66%)	140 (112%)	81 (65%)	89 (71%)
Oslo Lampén	59 (47%)	97 (78%)	62 (50%)	91 (73%)	74 (59%)	62 (50%)	40 (32%)	72 (58%)	...	58 (46%)
Oslo PFI	66 (53%)	102 (82%)	70 (56%)	110 (88%)	74 (59%)	69 (55%)	59 (47%)	91 (73%)	50 (40%)	76 (61%)
Korsnäs Valley	69 (55%)	94 (75%)	72 (58%)	99 (79%)	83 (66%)	60 (48%)	48 (38%)	78 (62%)	40 (32%)	63 (50%)
Skönsmon B & S	83 (66%)	112 (90%)	88 (70%)	129 (103%)	91 (73%)	76 (61%)	58 (46%)	108 (86%)	35 (28%)	79 (63%)
Helsingfors Valley	150 (120%)	240 (192%)	160 (128%)	261 (209%)	169 (135%)	142 (114%)	114 (91%)	198 (158%)	87 (70%)	141 (113%)
Helsingfors N & W	151 (121%)	225 (180%)	158 (126%)	243 (194%)	177 (142%)	145 (116%)	109 (87%)	195 (156%)	84 (67%)	145 (116%)
Aylesford	178 (142%)	281 (225%)	192 (154%)	317 (254%)	191 (153%)	170 (136%)	136 (109%)	234 (187%)	88 (70%)	151 (121%)
Korsnäs B & S	73 (58%)	99 (79%)	74 (59%)	127 (102%)	78 (62%)	71 (57%)	60 (48%)	104 (83%)	54 (43%)	82 (66%

Table D. Burst Factor (Mullen) at 50°S.-R. Based on the British Method of Sheetmaking

Beater	Extra strong unbleached sulphite	Kraft	Extra strong bleached sulphite	L & S sulphate	E.B. sulphite	Strong bleached sulphite	Soft bleached sulphite	E.B. sulphate	Bleached aspen	Rayon
Helsingfors Lampén	91.9 (100%)	90.1 (98%)	78.7 (86%)	74.2 (81%)	62.9 (68%)	54.8 (60%)	40.7 (44%)	42.9 (47%)	37.8 (41%)	26.6 (29%)
Oslo Lampén	89.1 (83%)	93.9 (102%)	73.0 (79%)	79.2 (86%)	59.6 (65%)	47.8 (52%)	35.2 (38%)	47.5 (52%)	...	23.8 (26%)
Oslo PFI	79.1 (86%)	96.8 (105%)	67.2 (73%)	84.4 (92%)	62.9 (68%)	47.1 (51%)	41.6 (45%)	60.3 (66%)	29.9 (33%)	36.3 (39%)
Skönsmon B & S	73.9 (80%)	68.7 (75%)	56.9 (62%)	65.2 (71%)	50.3 (55%)	39.3 (43%)	32.1 (35%)	48.3 (53%)	20.7 (23%)	30.1 (33%)
Helsingfors Valley	74.2 (81%)	96.8 (105%)	65.9 (72%)	80.8 (88%)	58.7 (64%)	47.8 (52%)	42.0 (46%)	57.6 (63%)	32.9 (36%)	37.1 (40%)
Helsingfors N & W	75.5 (82%)	78.7 (86%)	59.3 (65%)	71.1 (77%)	54.3 (59%)	42.8 (47%)	35.0 (38%)	54.8 (60%)	27.5 (30%)	34.3 (37%)
Aylesford	70.8 (77%)	70.9 (77%)	51.2 (56%)	61.4 (67%)	42.5 (46%)	33.3 (36%)	29.0 (32%)	42.1 (46%)	23.1 (25%)	23.6 (26%)

Table E. Breaking Length at 50°S.-R. Based on the British Method of Sheetmaking

Beater	Extra strong unbleached sulphite	Kraft	Extra strong bleached sulphite	L & S sulphate	E.B. sulphite	Strong bleached sulphite	Soft bleached sulphite	E.B. sulphate	Bleached aspen	Rayon
Helsingfors Lampén	12,300 (100%)	11,520 (94%)	10,360 (84%)	10,240 (83%)	9130 (74%)	8390 (68%)	7070 (57%)	6900 (56%)	6790 (55%)	5170 (42%)
Oslo Lampén	12,000 (98%)	11,910 (97%)	9,920 (81%)	10,430 (85%)	8600 (70%)	7390 (60%)	6050 (49%)	7420 (60%)	...	4360 (35%)
Oslo PFI	10,650 (87%)	11,390 (93%)	8,820 (72%)	10,140 (82%)	8660 (70%)	6820 (55%)	6000 (49%)	8050 (65%	4900 (40%)	5240 (43%)
Skönsmon B & S	9,600 (78%)	8,470 (69%)	7,820 (64%)	8,120 (66%)	6740 (55%)	5600 (46%)	4580 (37%)	6240 (51%)	3870 (31%)	4040 (33%)
Helsingfors Valley	10,570 (86%)	11,740 (96%)	8,890 (72%)	10,350 (84%)	8340 (68%)	7100 (58%)	6290 (51%)	8250 (67%)	6040 (49%)	5870 (48%)
Helsingfors N & W	10,530 (86%)	10,220 (83%)	7,980 (65%)	8,950 (73%)	7660 (62%)	6370 (52%)	5400 (44%)	7550 (61%)	5070 (41%)	5000 (41%)
Aylesford	9,950 (81%)	9,350 (76%)	7,400 (60%)	7,650 (62%)	6520 (53)%	5280 (43%)	4800 (39%)	5810 (47%)	4550 (37%)	3650 (30%)

Table F. Tear Factor at 50°S.-R. Based on the British Method of Sheetmaking

Beater	Extra strong unbleached sulphite	Kraft	Extra strong bleached sulphite	L & S sulphate	E.B. sulphite	Strong bleached sulphite	Soft bleached sulphite	E.B. sulphate	Bleached aspen	Rayon
Helsingfors Lampén	141 (100%)	215 (152%)	148 (105%)	221 (157%)	147 (104%)	129 (91%)	87 (62%)	155 (110%)	94 (67%)	96 (68%)
Oslo Lampén	145 (103%)	212 (150%)	144 (102%)	210 (149%)	152 (108%)	133 (94%)	95 (67%)	163 (115%)	...	112 (79%)
Oslo PFI	155 (110%)	233 (165%)	169 (120%)	267 (189%)	167 (118%)	149 (106%)	122 (87%)	198 (140%)	97 (69%)	163 (116%)
Skönsmon B & S	183 (130%)	263 (187%)	196 (139%)	283 (201%)	207 (147%)	180 (128%)	133 (94%)	236 (167%)	95 (67%)	190 (135%)
Helsingfors Valley	163 (116%)	257 (182%)	177 (126%)	284 (201%)	167 (118%)	152 (108%)	121 (86%)	207 (147%)	100 (71%)	153 (109%)
Helsingfors N & W	162 (115%)	246 (174%)	174 (123%)	262 (186%)	187 (133%)	158 (112%)	123 (87%)	208 (148%)	100 (71%)	158 (112%)
Aylesford	142 (101%)	221 (157%)	160 (113%)	261 (185%)	160 (113%)	143 (101%)	111 (79%)	203 (144%)	80 (57%)	134 (95%)

Our New CAMBIO Barker

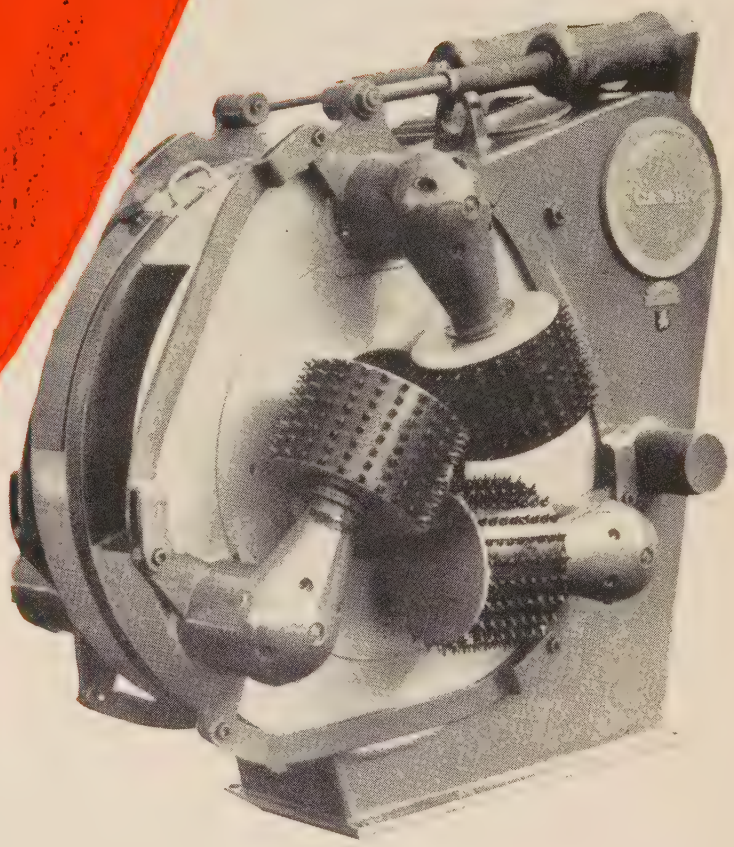

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Table G. Scattering Coefficient at 50°S.-R. Based on the British Method of Sheetmaking

Beater	*Extra strong unbleached sulphite*	*Kraft*	*Extra strong bleached sulphite*	*L & S sulphate*	*E.B. sulphite*	*Strong bleached sulphite*	*Soft bleached sulphite*	*E.B. sulphite*	*Bleached aspen*	*Rayon*
Helsingfors Lampén	110 (100%)	165 (150%)	128 (116%)	189 (172%)	155 (141%)	154 (140%)	184 (167%)	275 (250%)	256 (233%)	320 (291%)
Oslo Lampén	128 (116%)	169 (154%)	159 (145%)	224 (204%)	188 (171%)	108 (189%)	260 (236%)	281 (255%)	...	374 (340%)
Oslo PFI	162 (147%)	197 (179%)	211 (192%)	227 (206%)	225 (205%)	262 (238%)	316 (287%)	286 (260%)	403 (366%)	378 (344%)
Skönsmon B & S	216 (196%)	257 (234%)	268 (244%)	262 (238%)	317 (228%)	369 (335%)	378 (344%)	338 (307%)	512 (465%)	486 (442%)
Helsingfors Valley	167 (152%)	208 (189%)	211 (192%)	229 (208%)	241 (219%)	279 (254%)	308 (280%)	302 (275%)	369 (335%)	409 (372%)
Helsingfors N & W	176 (160%)	219 (199%)	239 (217%)	241 (219%)	274 (249%)	313 (285%)	338 (307%)	304 (276%)	426 (387%)	437 (397%)
Aylesford	174 (158%)	245 (223%)	273 (248%)	293 (266%)	314 (285%)	358 (325%)	379 (345%)	358 (325%)	433 (394%)	526 (478%)

clearly indicates that there is a fair similarity in the curves. The curves for tearing strength, however, are in closer proximity to each other due to the uniform basis of calculation. The breaking length and bursting strength curves have moved higher on the scale mainly because the absolute values of these strength properties increase when the basis of calculation is the moisture-free basis weight (British method) and not the air-dry

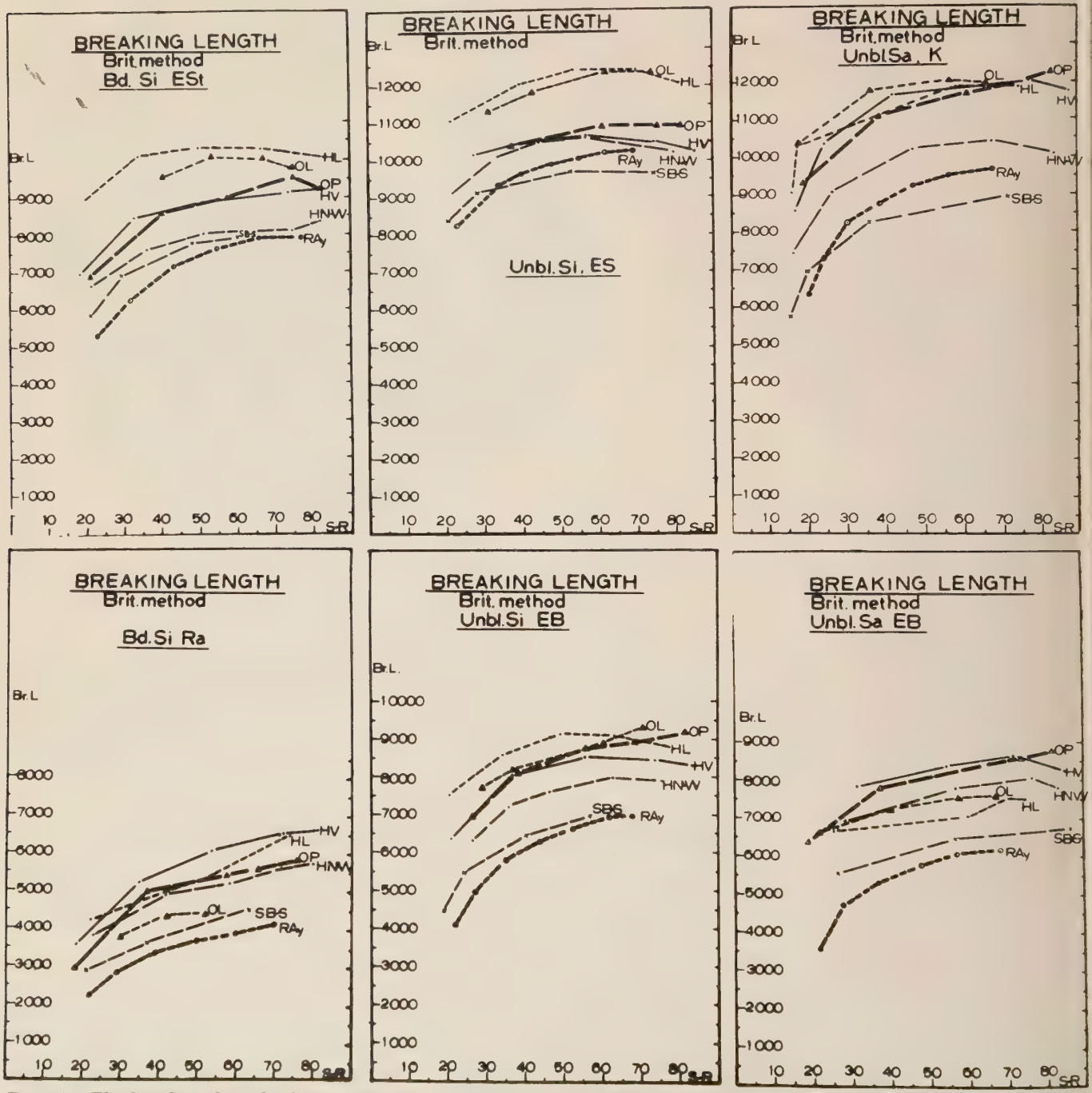

Fig. 14. The breaking length of pulp samples: bleached sulphite BES, bleached rayon sulphite, Ra, unbleached grease-proof sulphite UES, easy bleaching sulphite, UEB, unbleached kraft sulphate, K and easy bleaching sulphate EB, for the various beaters as a function of the S.-R. values; sheets made and tested according to the British method

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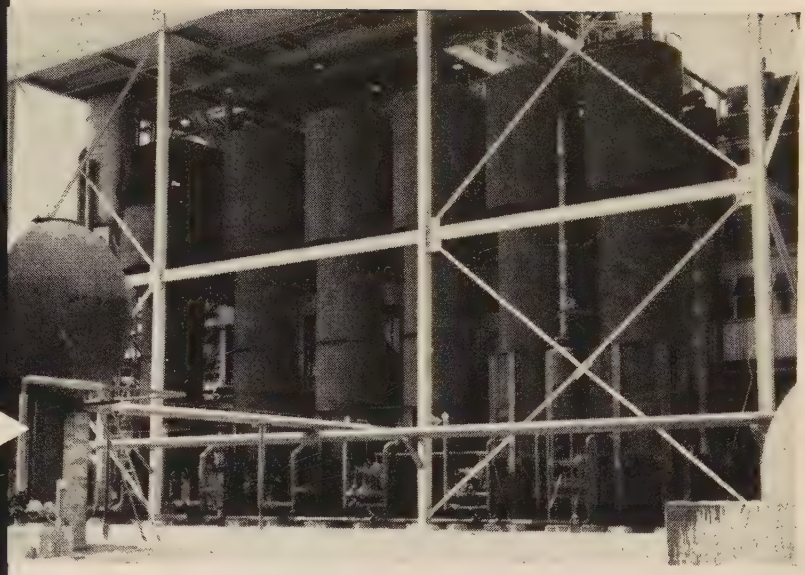

Above: Conkey Sextuple Effect Integral Evaporator installed in large southern pulp mill, concentrating soda liquors for kraft pulp and higher grade cellulose.

It's profit in the making . . . with pulp and paper equipment built for economical production in step with new processes. The Conkey Sextuple Effect Evaporators above are designed to concentrate soda liquors for kraft pulp and higher grade cellulose. The four 2,700 cu. ft. digesters at the left are being erected for the direct cooking of wood chips by the sulphate process.

These are typical examples of CB&I specialized structures built for a specialized industry. Information on equipment for your plant may be obtained by writing our nearest office.

Left: Four 2,700-cu. ft. digesters built by CB&I. They are designed for 150 lb. per sq. in. operating pressure and temperatures up to 650 deg. Fahr.

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basis weight, which is customary in the Nordic countries.

The *tensile* curves, Fig. 8, according to the British method for the different pulps in the various beaters are, with the exception of the Lampén mills, surprisingly parallel.

The absolute tensile values of all pulps are lowest and mutually of the same order after beating in the Aylesford beater and the B & S beater. The highest values, in average about 3000 m. higher, are obtained for strong pulps in the two Lampén mills, of which the mill in Helsingfors gives higher values for sulphites and slightly lower values for sulphates than the mill in Oslo. For rayon and E B sulphate the Lampén mills give lower values than the PFI mill, the Valley beater and even the N & W beater. The strength figures of these pulps obtained in the Lampén mills approach those obtained in the B & S beater and the Aylesford beater. The fact that the Lampén mill gives exceptionally low strength values for extremely well digested and strongly bleached pulps in comparison with other beaters has previously been observed by Ekstam (*12*). There is a correlation, between the tensile values obtained in the PFI mill and in the Valley beater in Helsingfors with the exception of those for the softer bleached pulps, which, in the PFI mill, were beaten at a lower beating pressure than the stronger pulps, and the values are on the average about 1000 m. higher than those obtained in the N & W beater. The PFI and Valley curves for strong sulphites lie halfway between the Lampén and

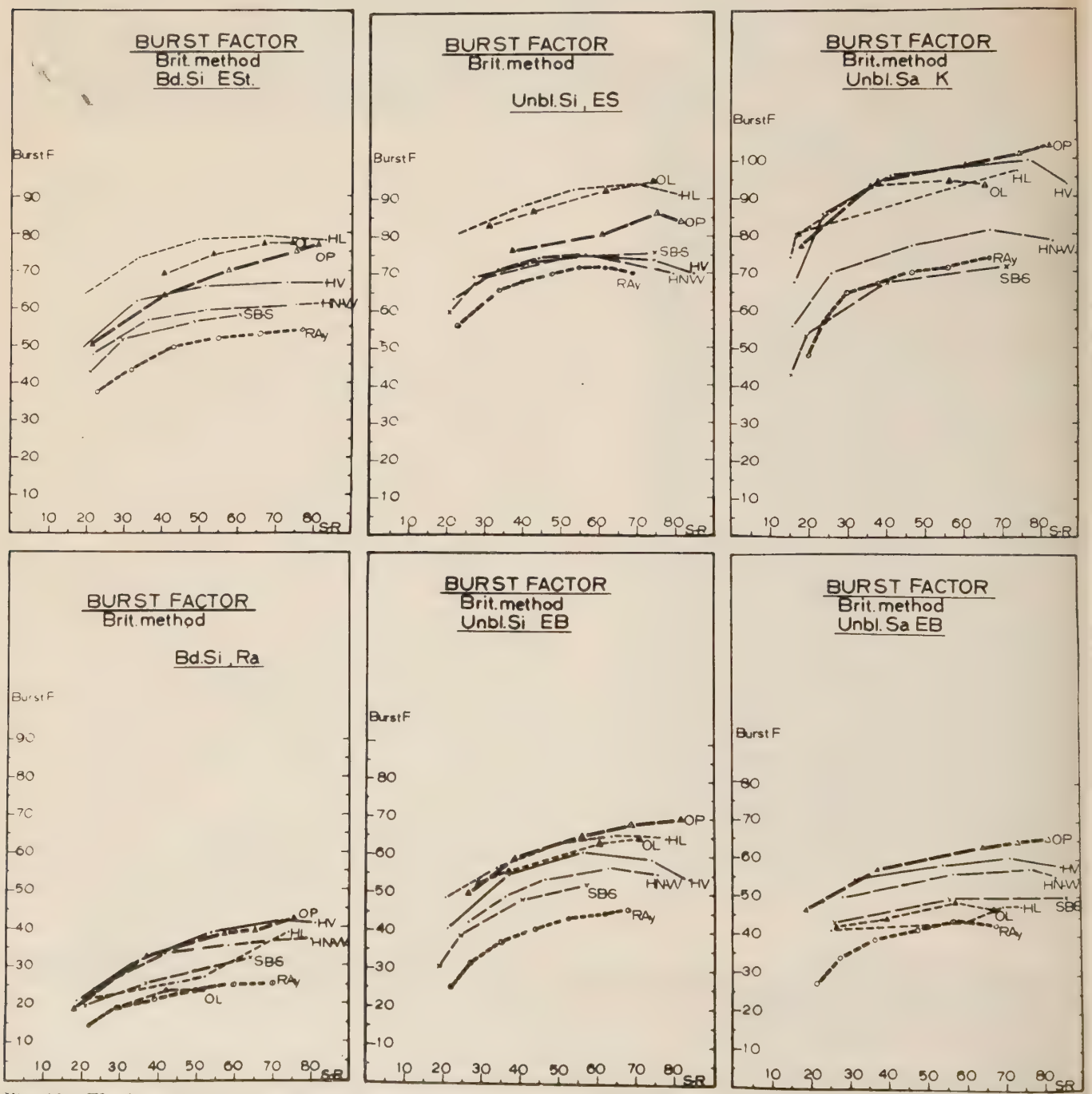
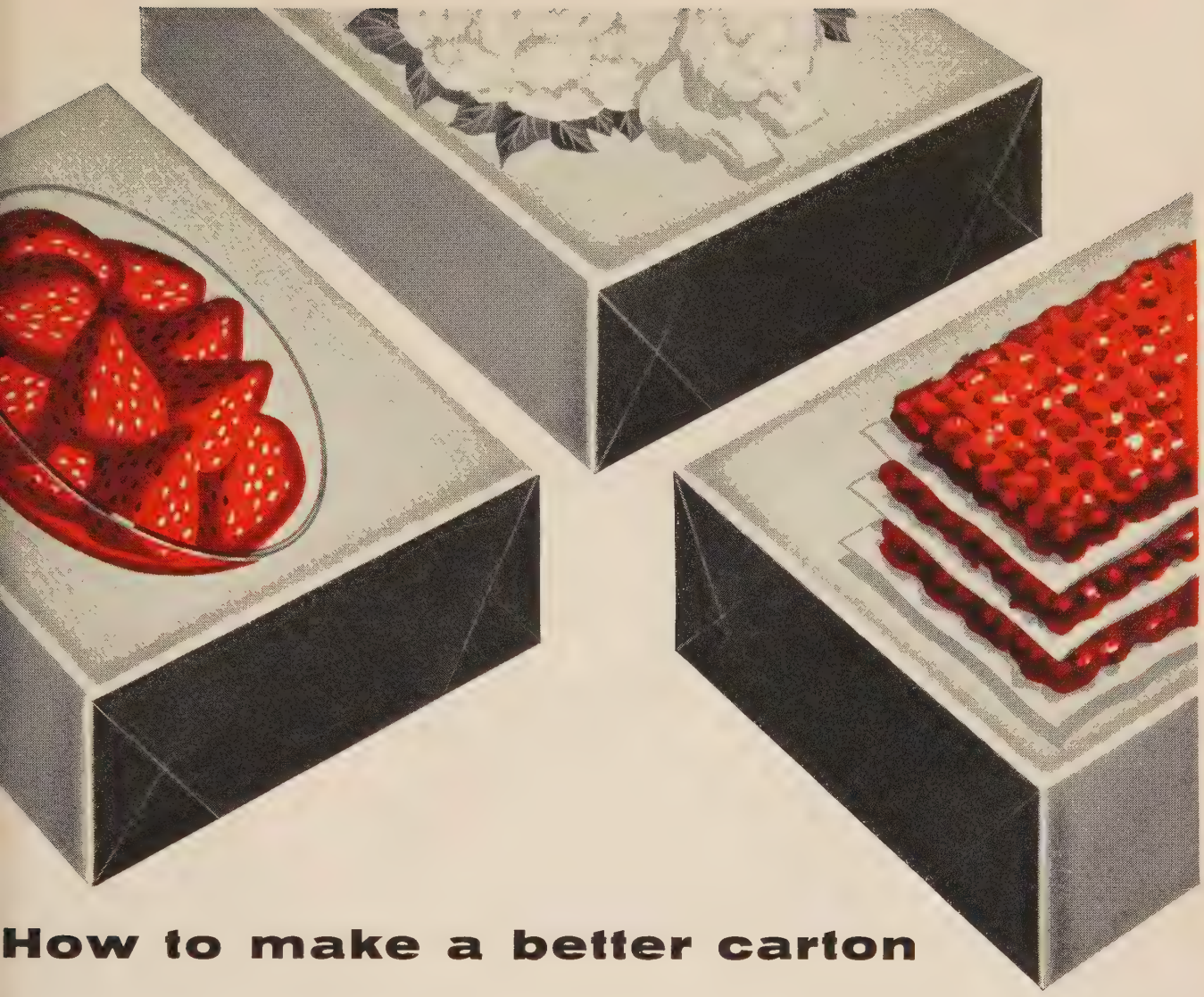


Fig. 15. The burst factor of pulp samples: bleached sulphite BES, bleached rayon sulphite, Ra, unbleached greaseproof sulphite UES, easy bleaching sulphite, UEB unbleached kraft sulphate, K and easy bleaching sulphate EB, for the various beaters as a function of the S.-R. values; sheets made and tested according to the British method



How to make a better carton

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☐ Candles		☐ Match wax
☐ Candy wrappers	☐ Fabric sizing	☐ Milk bottle caps
☐ Cartons, butter	☐ Fiber plates	☐ Milk cartons
☐ Cartons, frozen food	☐ Florist paper	☐ Waterproofing
☐ Cartons, ice cream	☐ Other use_____	

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B & S Aylesford curves, for soft sulphites and sulphates higher than the Lampén curves and for strong sulphates on the same level as the latter.

The *burst factor* curves, Fig. 9, are mainly similar to the tensile curves. Except in the case of the aspen and kraft qualities the B & S beater gives higher bursting values than the Aylesford beater throughout. The tendency of the Lampén mill to give lower strength figures for soft pulps is here still more pronounced.

The tearing strength curves are also nearly parallel. The *tear factor*, Fig. 10, except for the aspen quality, is throughout lowest when the pulp is beaten in the Lampén mill, and highest after beating in the B & S beater. Here again the values obtained in the PFI mill and the Valley beater are comparable. The values are fairly close to those obtained in the N & W beater and, except for the aspen quality, lie halfway between the values obtained in the B & S beater and the Lampén mill. The tearing strength figures obtained in the Aylesford beater are considerably lower than those of the B & S beater, which indicates that the beatings in these two beaters, in spite of similarities in tensile and bursting strength and, as will be later shown, opacity, are of a different nature. The tearing values of the Aylesford-beater lie halfway between the Lampén and the PFI-Valley values for sulphites and on the same level as the PFI-Valley values for sulphates.

The *folding endurance*, Fig. 11, according to the Schopper test, seems as a rule to be lowest, for all pulp qualities, when the pulps have been beaten in the Ayles-

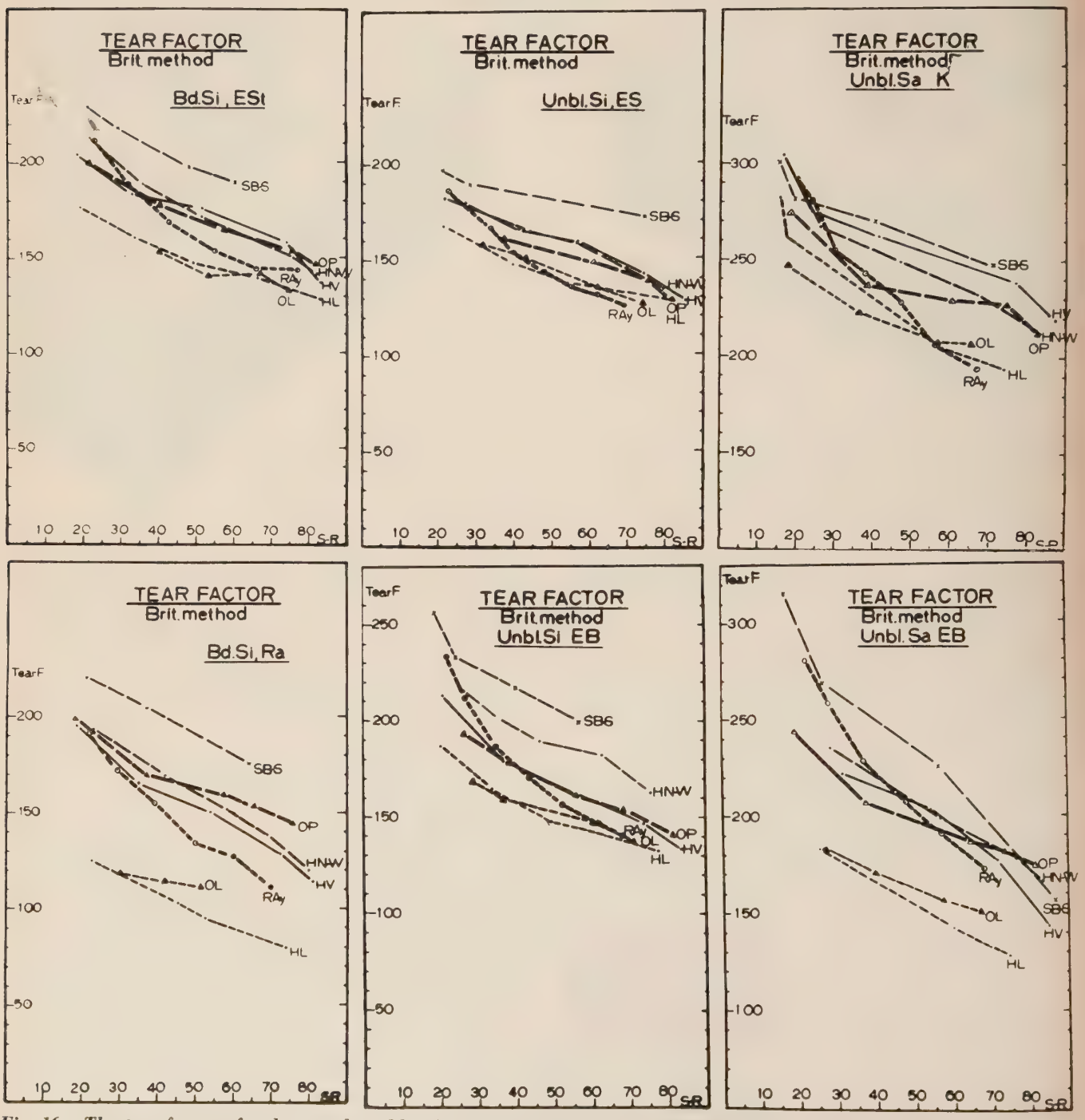

Fig. 16. The tear factor of pulp samples: bleached sulphite BES, bleached rayon sulphite, Ra, unbleached greaseproof sulphite UES, easy bleaching sulphite, UEB, unbleached kraft sulphate, K and easy bleaching sulphate EB, for the various beaters as a function of the S.-R. values; sheets made and tested according to the British method

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ford beater and the B & S beater and highest for sulphates and soft sulphites after beating in Valley and PFI beaters. For strong bleached and unbleached sulphites the Lampén mill gives the highest folding endurance number. Generally speaking the order of the beating apparatus is the same as in the case of the tensile strength.

Opacity, Fig. 12, expressed as scattering coefficient, grades the beaters generally in the same order as the tear factor with the exception that the opacity curves for the B & S beater and the Aylesford beater practically coincide. The Lampén mill, and especially the mill in Helsingfors, gives the lowest scattering coefficients and the B & S beater and the Aylesford beater give the highest. In this case also there is an astonishingly good agreement between the values obtained after beating in the PFI mill and the Valley beater. The values are lower than those obtained in the N & W beater and are about half-way between the Lampén and the B & S Aylesford curves.

The *apparent specific gravity*, Fig. 13, is throughout lowest after beating in the B & S beater and highest after beating in the two Lampén mills. There is a fairly good correlation, between the PFI mill and the Valley beater and, surprisingly, between these beaters and the Aylesford beater. The apparent specific gravity values after beating in the N & W beater are somewhat lower than the Aylesford values.

For the sake of clarity and in order to get a common basis of comparison for the various beaters, only

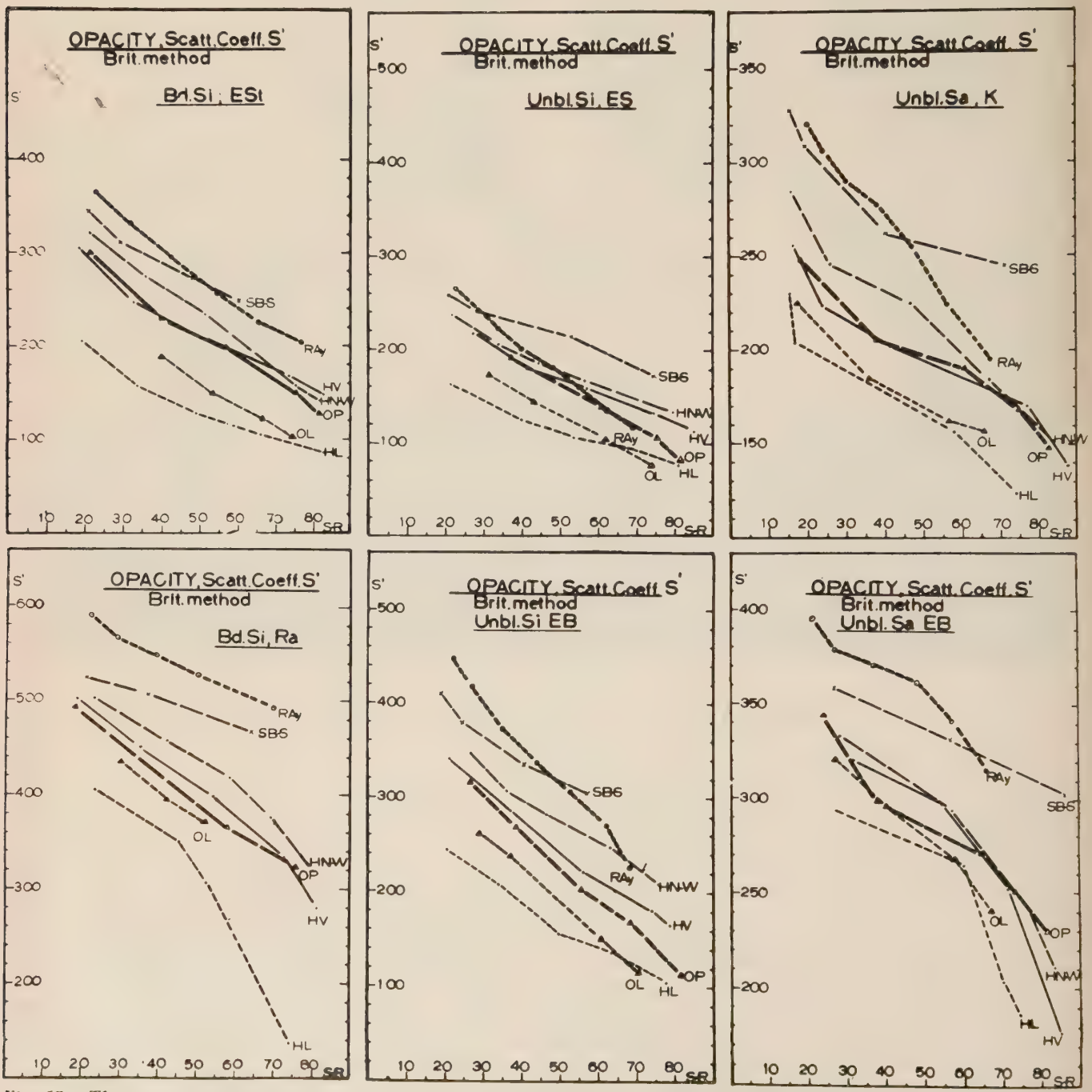

Fig. 17. The opacity, scattering coefficient of pulp samples: bleached sulphite BES, bleached rayon sulphite, Ra, unbleached greaseproof sulphite UES, easy bleaching sulphite, UEB, unbleached kraft sulphate, K and easy bleaching sulphate EB, for the various beaters as a function of the S.-R. values; sheets made and tested according to the British method

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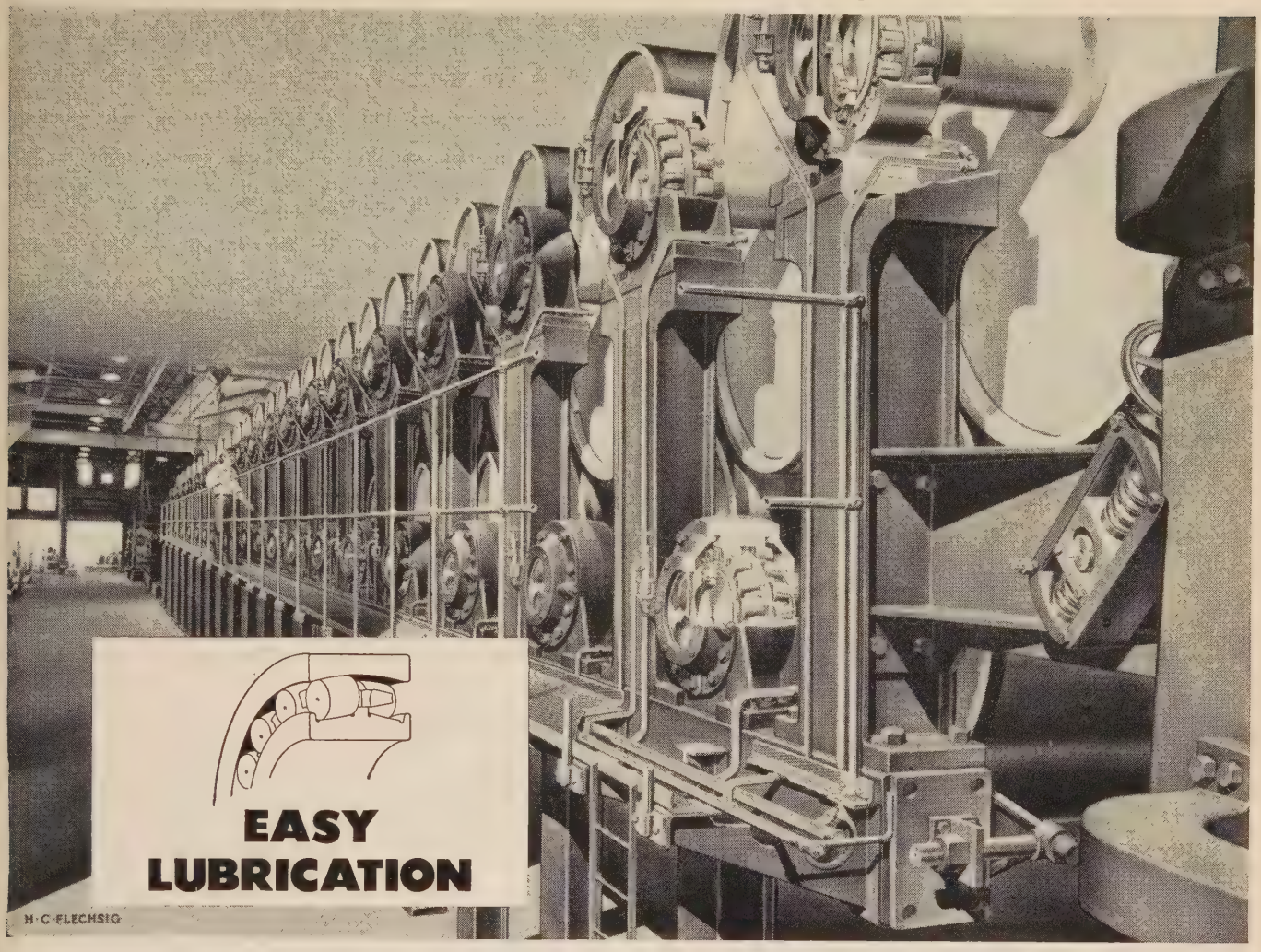

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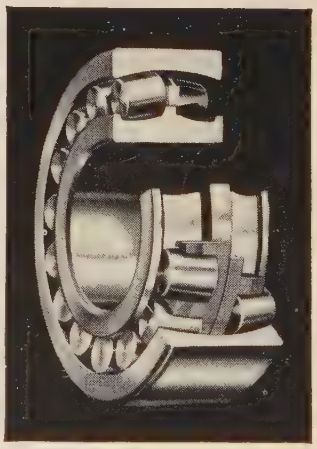

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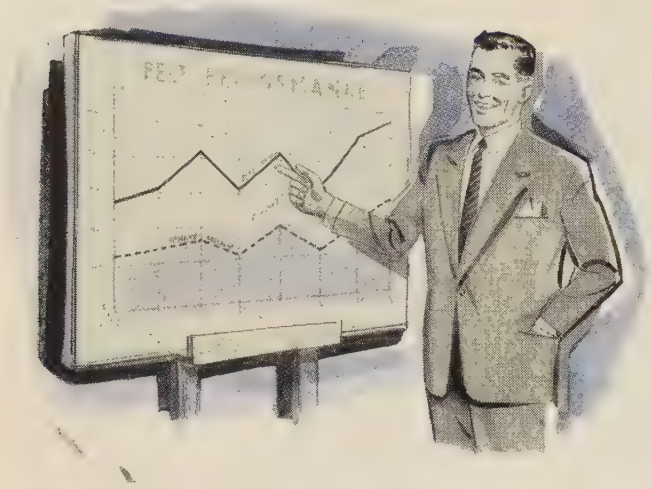
how felt records help you get



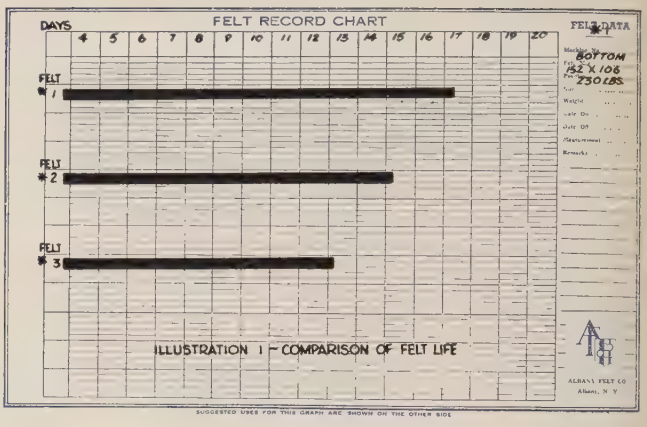
Since the war, paper and paperboard production has increased about 32%, yet felt production for the same period increased only 9%. Expressed differently, the average pound of felt is now doing about 21% more work. There are two reasons for this:

1. Better felts are being made.
2. Papermakers are getting improved performance from their felts.

Contributions toward better felt quality by Albany Felt during this period have included dramatic developments in synthetic-content felts, chemical treatments, and in felt designing — with continuous research under way to provide even better felts in the future. Albany Felt Company has also worked with the paper industry to develop an improved method of keeping felt records, which in turn has helped papermakers measure their efficiency and translate this information into "more saleable tons per day."

Felt records are useful only if they help to increase the profit position of the paper mill operation. To illustrate this point, let's look at a typical series of records for three felts which were used on a specific machine position. Pertinent material is tabulated on Albany Felt Chart No. 54R, an 8" x 14" sheet widely used in the industry. It is ideal for graphically recording four separate aspects of felt performance:

1. Felt life
2. Tons of paper produced
3. Felt cost per ton
4. Daily production

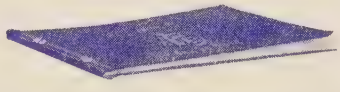


Comparison of Felt Life

In Illustration 1, the life of the three felts being studied has been charted in days, with Felt #1 making the best showing by lasting nearly 17 days. Some mills use this as a sole measurement of felt performance; but as we proceed, it should be obvious that this presents only a small part of the picture and may, in itself, give an erroneous impression.

Comparison of Tons Produced

Illustration 2 shows the tons produced by the three felts; and here again, Felt #1 leads the others with a total production of more than 1600 tons. This, of course, gives insight to another important facet of felt performance, but still leaves several important factors uncovered.



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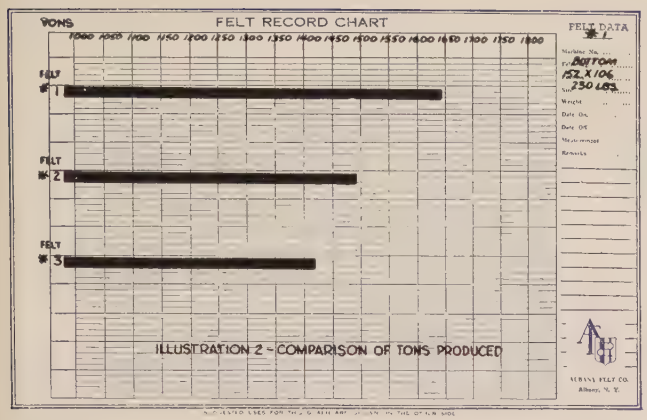
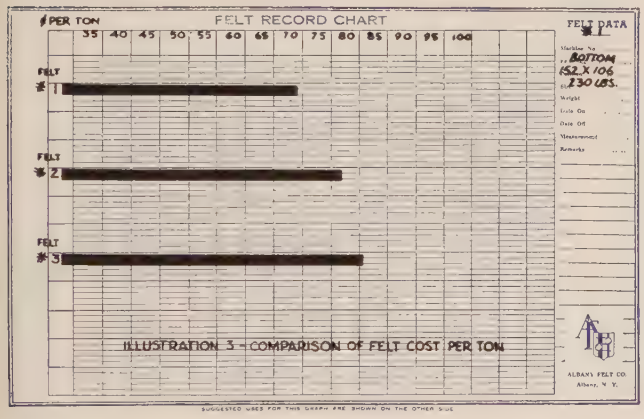
"more saleable tons per day"



Comparison of Felt Cost per Ton

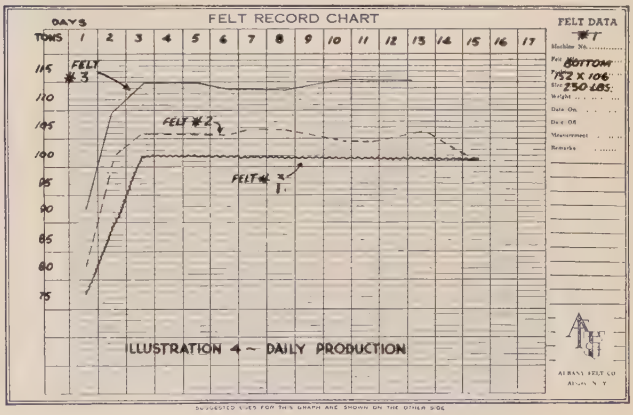
In examining this item, shown in Illustration 3, we find that Felt #1 is still the leader, with its figure of 70¢



the lowest cost per ton of the three felts studied. Traditionally, felt cost-per-ton has been an important standard for evaluating felts, but today, more and more mills are learning that fast, trouble-free performance at all times is much more important than squeezing the most tonnage from each felt.

Comparison of Daily Average Production

Accordingly, we now chart the average daily production, as shown in Illustration 4. This shows which felt is providing greatest over-all mill efficiency.



We note that Felt #1 appears to be the best felt and Felt #3 the poorest when charted against the usual standards of days life, tons produced and cost per ton. However, when the same data is charted on the production per day basis *#1 is the poorest* and *#3 the best felt!* Certainly the decreased direct and indirect mill costs per ton resulting from this additional 14 tons of production per day will more than pay for the slight increase in felt cost and changeovers. Mill profit is definitely enhanced. The importance of this final chart cannot be over-emphasized, inasmuch as felt performance must necessarily be related to other operating costs such as steam, labor and general overhead. In the final analysis, the felt that produces "more saleable tons per day" is to be preferred.

Although this is a single example, the principles involved can undoubtedly be applied to your own felt record-keeping. For a more detailed explanation of this vital function, see the new Albany Felt handbook entitled "Suggestions for Improved Felt Performance" or ask your Albany Felt Sales Engineer to help you set up the records you need to show which felts are giving you the most efficient performance.

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strength values for a wetness of 50°S.-R. have been presented above. In order to illustrate the results presented and to obtain some idea of the whole beating process in the different beating apparatus the *breaking length, burst factor, tear factor,* and *opacity* of two extreme unbleached sulphites, two bleached sulphites and two unbleached sulphates were plotted against the S.-R. number (Figs. 14 to 17). From the diagram it is evident that the strength curves obtained with the different beaters are fairly parallel. A certain downward trend in the tensile and burst curves toward the end of the beating observed for the Helsingfors values is due to difficulties experienced in this laboratory in forming perfect sheets in the British sheet mold at wetnesses of 70 to 80°S.-R. It is also observed that the curves illustrating the tear and the scattering coefficient after beating in the Aylesford beater tend to intersect the corresponding curves obtained after beating in other beaters as the beating proceeds. These values are higher at the beginning of the beating and lower at the end of the beating than most of the corresponding values obtained in other beaters. It is also observed that the strength curves for all pulp qualities obtained in the PFI mill and in the Valley beater follow each other surprisingly well during the whole beating considering the fact that the sheetmaking although carried out according to the same method has been performed in different laboratories.

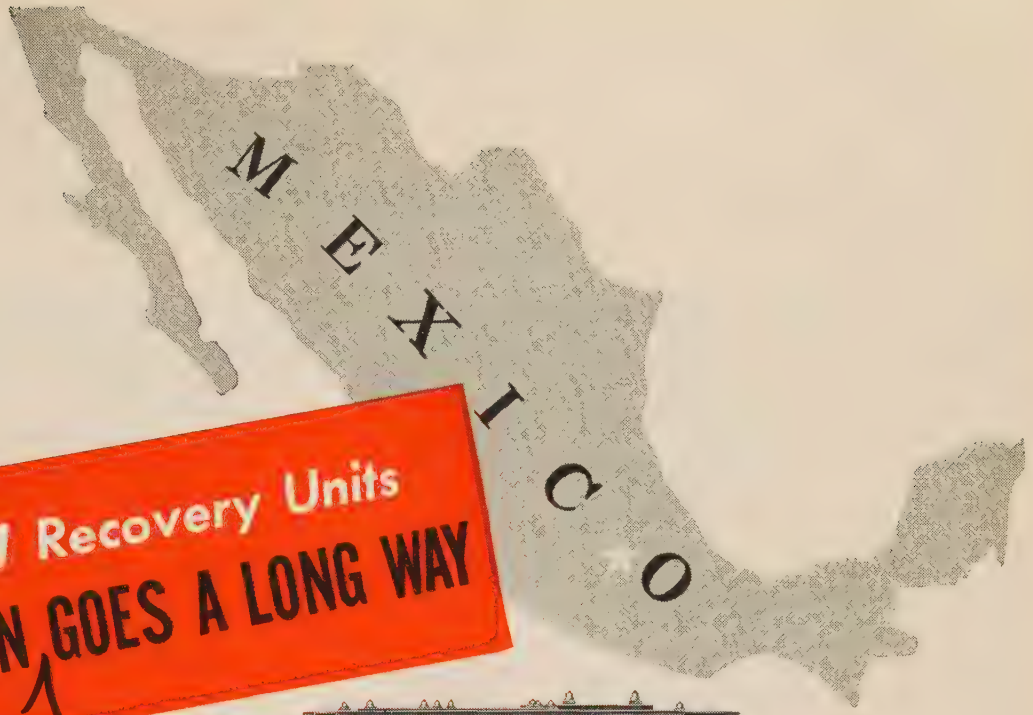
The results obtained with the two Lampén mills also correspond fairly well, although an uncertainty can be found in their working which is evident in the difficulties to beat soft pulps. The tendency of the Lampén mills to give strength values for soft pulps, which in comparison with strength values for strong pulps are lower than the corresponding values obtained in other beating apparatus, is more apparent in the complete beating curves than in the 50°S.-R. curves. In the case of EB-sulphate and rayon the tensile curves obtained in the Lampén mills are lower than those obtained in the N & W beater, and the Mullen values are even lower than those obtained in the B & S beater, while on the other hand the values for stronger pulps, e.g., ES bleached sulphite, are considerably higher than the corresponding values obtained in the PFI mill and the Valley beater, although no appreciable change in the relationship between the strength values in the two latter beaters and in the B & S beater has occurred. No corresponding increase in the tear figures obtained in the Lampén mill for the softer pulps can be observed, and these values are also lower than those obtained in the other beaters for these pulps.

Grading. The assessment of the laboratory beaters may be more satisfactorily considered when one method of sheetmaking is adopted, namely the British method. For ease of comparison, Tables, D, E, F, and G are set out in a similar manner to Tables A, B, and C. They show the values for burst factor, breaking length, tear factor, and scattering coefficient taken from the average

Table H. Reproducibility of Burst Factor at 50°S.-R. Based on the British Method of Sheetmaking

Beater	*Extra strong unbleached sulphite*	*Kraft*	*Extra strong bleached sulphite*	*L & S sulphate*	*E.B. sulphite*	*Strong bleached sulphite*	*Soft bleached sulphite*	*E.B. sulphate*	*Bleached aspen*	*Rayon*
Helsingfors	91.0	93.0	78.4	75.0	63.0	56.0	39.8	44.5	37.0	26.5
Lampén	93.5	92.0	79.3	72.0	62.5	53.0	41.0	43.0	37.5	26.0
	92.5	89.0	78.0	74.0	63.0	56.2	40.0	41.5	37.7	27.5
Av.	92.3	91.3	78.6	73.7	62.8	55.1	40.3	43.0	37.4	26.7
Oslo Lampén	86.0	94.0	72.7	79.0	59.0	48.5	32.5	47.5	...	24.7
	91.0	94.0	75.0	79.5	60.5	46.5	36.8	48.0	...	23.0
	92.5	98.0	73.0	77.5	60.0	47.3	35.8	47.0	...	24.3
Av.	89.8	95.3	73.6	78.7	59.8	47.4	35.0	47.5	...	24.0
Oslo PFI	78.5	96.0	67.6	83.0	62.0	49.5	42.0	59.5	30.5	38.2
	80.5	100.0	64.5	85.0	62.5	44.0	41.5	59.0	29.0	37.7
	79.5	97.0	70.0	83.0	64.0	48.5	42.0	63.0	29.0	33.3
Av.	79.5	97.7	67.4	83.7	62.8	47.3	41.8	60.5	29.5	36.4
Korsnäs Valley[a]	68.5	75.0	62.0	65.5	48.5	39.0	34.0	51.5	21.5	34.0
	69.5	73.5	61.8	68.0	50.0	41.0	32.3	52.0	22.0	32.8
	63.5	71.0	58.8	69.5	49.0	42.5	33.5	52.5	21.0	35.5
	65.0									
Av.	66.6	73.2	60.9	67.3	49.2	40.8	33.3	52.0	21.5	34.1
				58.0						
Skönsmon B. S.	74.0	70.0	57.0	63.0	50.5	40.0	31.3	50.0	22.0	30.0
	75.0	66.0	55.0	67.5	60.5	38.5	32.5	50.5	19.5	31.5
	74.5	71.0	57.0	66.0	49.5	40.0	32.5	47.5	21.0	28.5
			56.0							
Av.	74.5	69.0	56.6	65.5	50.2	39.5	32.1	49.3	20.8	30.0
Helsingfors Valley	75.0	97.0	66.0	80.0	50.0	48.0	41.5	57.7	33.0	40.0
	73.5	98.0	65.0	82.0	59.0	47.5	43.0	58.0	34.0	37.0
	74.5	98.0	66.8	82.5	60.5	49.0	42.5	59.0	32.5	36.5
Av.	74.3	97.7	65.9	81.5	59.8	48.2	42.3	58.2	33.2	37.8
Helsingfors N & W	72.5	79.0	59.5	71.5	54.0	42.5	36.0	54.0	28.5	35.0
	76.5	78.5	59.5	72.0	54.0	43.5	34.0	56.0	27.5	34.0
	77.5	80.0	59.4	70.5	55.0	43.2	34.8	57.0	27.5	34.5
	76.0				55.0					
Av.	75.6	79.2	59.5	71.3	54.5	43.1	34.9	55.7	27.8	34.5
Aylesford	70.5	71.0	52.0	62.5	43.0	33.3	29.0	44.0	22.2	22.5
	71.5	72.0	51.5	62.0	43.5	34.2	28.7	44.0	22.5	23.3
	72.0	70.0	51.5	61.0	42.5	34.0	29.8	41.5	23.0	24.8
Av.	71.3	71.0	51.7	61.8	43.0	33.8	29.2	43.2	22.6	23.5
Korsnäs B. S.[a]	59.0	68.5	53.0	64.0	39.5	37.5	34.0	53.0	25.4	30.0
	59.0	73.0	53.0	65.0	43.0	39.0	34.7	53.5	24.8	25.5
	82.5	76.0	48.5	68.0	47.0	38.0	33.5	53.0	23.0	28.5
		70.5								
Av.	58.7	72.0	51.5	65.7	43.2	38.2	34.1	53.2	24.4	28.0

[a] Lab's own method of sheetmaking.



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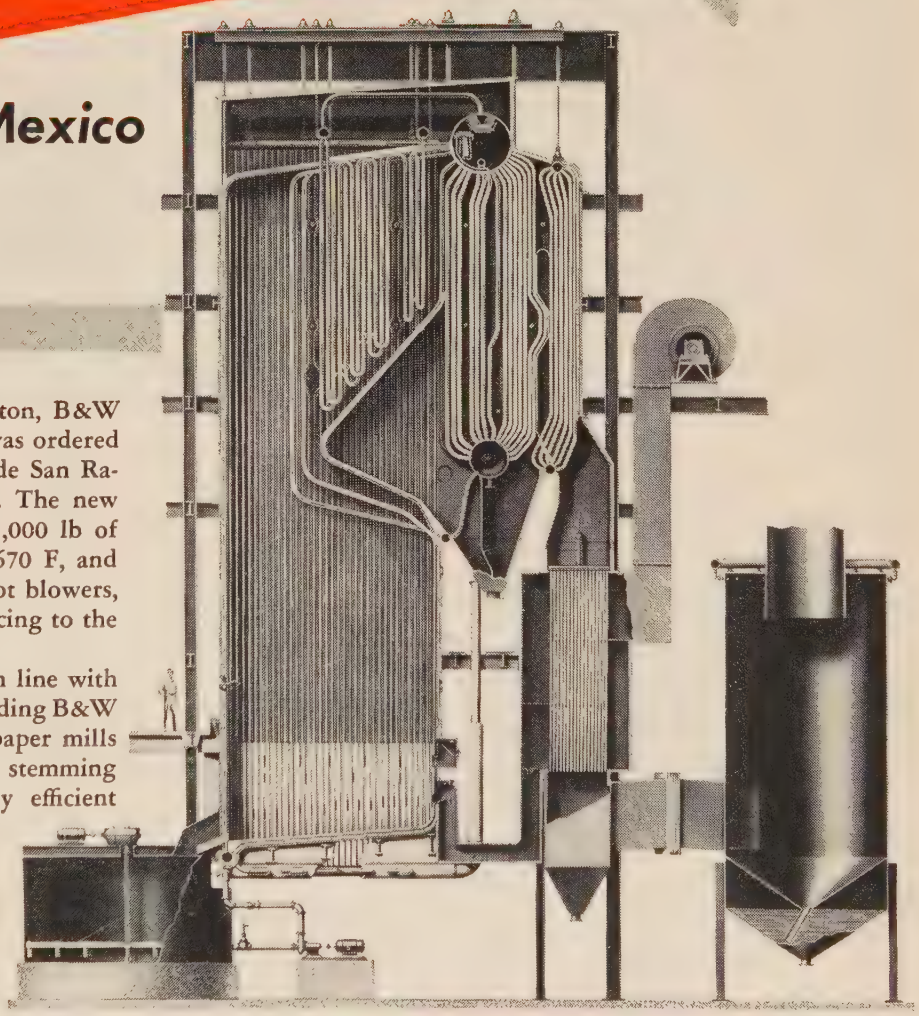

Typical B&W 2-Drum Recovery Unit equipped with B&W Cyclone Evaporator

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curves at 50°S.-R. Taking the value obtained by the Helsingfors Lampén for extra strong unbleached sulphite as 100%, the other values are calculated as a percentage of this value.

Further examples of the comparison between the beaters are shown in Figs. 18 to 23, in which the breaking length, burst factor, tear factor, folding endurance, scattering, coefficient, and apparent specific gravity at 50°S.-R. of all the pulp qualities have been plotted with the beating apparatus as a basis. The bleached and unbleached sulphites have been treated as a separate group, and the sulphates as another. From these diagrams, Figs. 18 to 23, it is evident that all beaters, definitely grade the different qualities, except rayon and aspen, in the same order in respect to their *breaking length*, *bursting strength*, and *opacity*. At first sight the *tear curves* (Fig. 21) for the bleached and unbleached sulphites do not seem to be equally conclusive but a close examination reveals that the unbleached sulphites between themselves and the stronger qualities of the bleached sulphites between themselves are graded in the same order by all the beating apparatuses. Only the curve for the rayon quality, in comparison with the other bleached qualities, appears irregular. From the tear curves it is also evident that the tearing strength of the weakest bleached qualities, soft and rayon, in comparison with other pulps, is much lower in the Lampén mill than in the other beaters.

With the exception of the sulphate qualities kraft and L & S, the various beaters grade the pulp qualities in the same order for *folding endurance* (Fig. 22). There is no clear uniformity in the *apparent specific gravity curves* (Fig. 23) where sulphates are concerned. For sulphites, however, provided the bleached and unbleached pulps are considered separately, a uniformity can clearly be observed in the case of bleached qualities. The order of the unbleached qualities EB and ES is however reversed in the N & W, B & S, and the Aylesford beater in comparison with the other beaters.

Because of the varying capacities of the beaters it is difficult to make any comparisons of *beating time*.

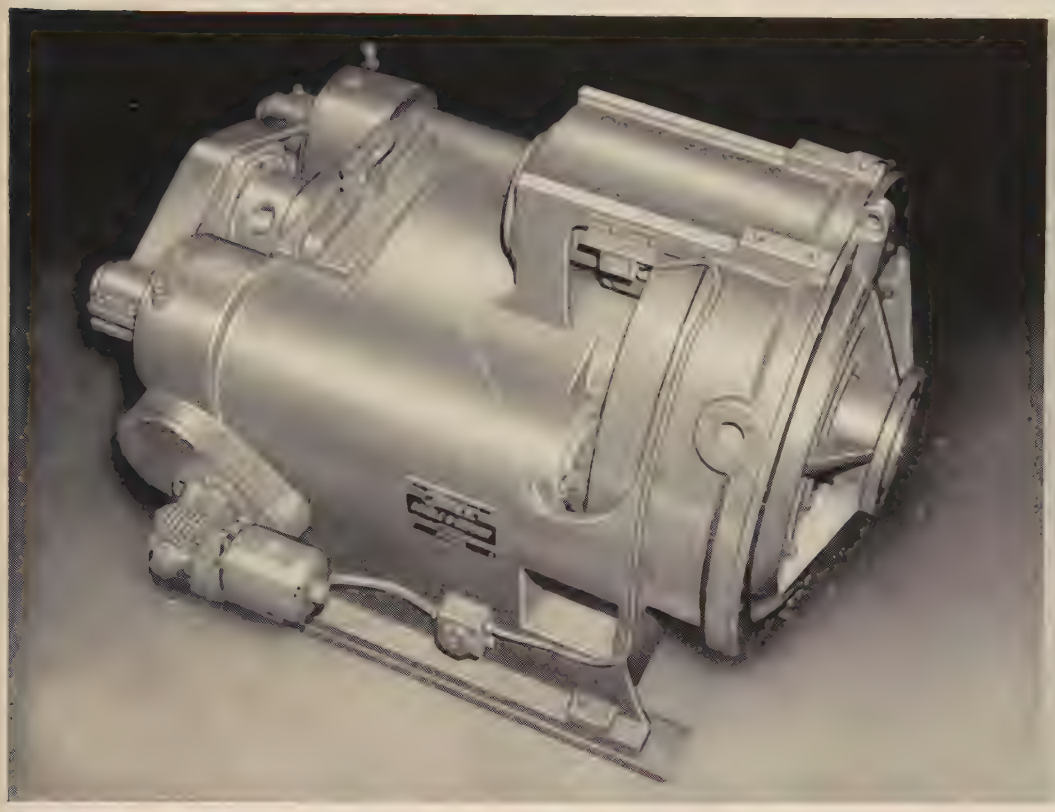
It appears that the various laboratory beaters grade the pulp qualities, with the exception of the softest bleached sulphite specialty pulps in the same order in respect to the strength properties but unfortunately not in respect to beating time. At the same time it has been shown that there is a correlation between the strength figures obtained in the PFI mill and the Valley beater. The strength values, with the exception of tearing strength, are also fairly close to each other when the beating is carried out in the Aylesford beater and the B & S beater. It has previously been shown by Cottrall (*2*) that the Aylesford laboratory beater corresponds well with the Aylesford mill beater and Ekstam has shown (*12*) that bleached sulphate pulps beaten in the Valley beater are graded in the same order with regard to their strength properties as when the pulps are beaten in mill beaters and the papers made from these

Table I. Reproducibility of Breaking Length at 50°S.-R. Based on the British Method of Sheetmaking

Beater	*Extra strong unbleached sulphite*	*Kraft*	*Extra strong bleached sulphite*	*L & S sulphate*	*E.B. sulphite*	*Strong bleached sulphite*	*Soft bleached sulphite*	*E.B. sulphate*	*Bleached aspen*	*Rayon*
Helsingfors	12,250	11,850	10,400	10,200	9100	8500	7180	7050	6750	5000
Lampén	12,500	11,900	10,300	10,200	9150	8520	7150	7000	6820	5250
	12,250	11,300	10,350	10,170	9100	8500	7050	6800	6720	5383
Av.	12,333	11,683	10,350	10,190	9117	8507	7127	6950	6763	5100
Oslo Lampén	11,900	11,850	10,350	10,250	8550	7500	5900	7650	...	4450
	12,150	11,850	10,000	10,350	8500	7250	6300	7550	...	4340
	12,050	12,400	9,760	10,350	8650	7450	5950	7100	...	4380
Av.	12,033	12,033	10,037	10,317	8567	7400	6050	7433	...	4253
Oslo PFI	10,600	11,300	8,950	10,000	8550	6900	6000	8100	4950	5000
	10,750	11.700	8,750	9,900	8550	6650	5800	7950	4700	5007
	10,700	11,400	8,730	9,800	8550	6980	6050	8150	4800	5400
Av.	10,683	11,467	8,810	9,900	8550	6843	5950	8067	4817	5240
Korsnäs Valley[a]	10,750	10,200	9,050	9,450	8250	6550	5750	7450	4400	5200
	11,200	10,000	8,950	9,300	8000	6750	5900	7000	4300	5000
	10,250	10,400	8,350	9,450	8250	6800	5800	7700	4450	5200
	10,750									
Av.	10,738	10,200	8,783	9,400	8167	6700	5817	7583	4383	5133
Skönsmon			8,150							
B & S	9,800	8,400	7,850	7,900	6750	5750	4500	6750	3940	4000
	9,800	8,600	7,450	8,400	6670	5650	4550	6150	3880	4050
	9,350	8,500	7,670	8,200	6700	5570	4750	6200	3800	4000
			7,780							
Av.	9,650	8,500	7,780	8,167	6707	5657	4600	6367	3873	4017
Helsingfors Valley	10,600	12,000	8,960	10,300	8450	7200	6350	8300	6050	5850
	10,500	11,700	8,880	10,400	8450	7100	6300	8250	6150	5950
	10,650	11,800	8,800	10,350	8450	7150	6350	8300	6130	6000
Av.	10,583	11,833	8,880	10,350	8450	7150	6333	8283	6110	5933
Helsingfors	10,300	10,300	8,000	9,050	7550	6200	5500	7650	5100	5050
N & W	10,700	10,000	8,030	8,950	7850	6500	5370	7600	5170	5100
	10,550	10,300	8,050	9,000	7800	6450	5400	7800	5100	4850
	10,700				7500					
Av.	10,563	10,200	8,027	9,000	7675	6383	5423	7683	5123	5000
Aylesford	10,050	9,300	7,800	7,700	6550	5400	4980	5900	4370	3550
	9,950	9,500	7,400	7,700	6650	5300	4870	6000	4450	3650
	10,000	9,200	7,300	7,000	6660	5250	4840	5700	4560	3750
Av.	10,000	9,333	7,500	7,667	6617	5317	4897	5867	4460	3650
Korsnäs	9,200	9,100	6,450	8,600	6250	5570	5150	7150	4450	4450
B & S	9,350	9,400	7,350	8,550	5950	5850	5350	7050	4600	4100
	9,050	9,900	7,000	8,800	6650	5730	4400	7400	4400	4500
		9,400								
Av.	9,200	9,450	6,933	8,650	6283	5717	4967	7200	4483	4350

[a] Lab's own method of sheetmaking.

Jones DOUBLE-D WITH DOUBLE EQUA-FLO EFFECT



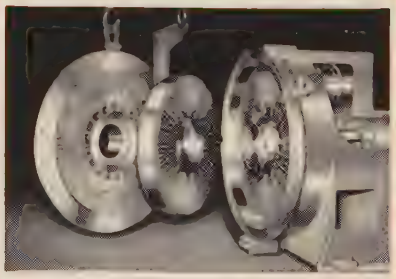
This overhead view illustrates the compactness of the Double-D. Very economical of floor space, it can be located and piped up in much the same manner as a conventional Jordan.

Consistently does the work of two or more conventional refiners . . .

You're looking at the new Jones Double-D Refiner first truly pressurized disc refiner — clean-lined, compact, easy to operate, easy to maintain . . . and already setting performance records.

For the Double-D is a *proven* machine. Full-scale production units have been in operation in several mills for as long as 18 months — and in fact several mills have already re-ordered.

They report stock quality equal or better than any other refiners, with substantial savings in time, horsepower and floor-space. Ask your Jones representative for details or write for Bulletin No. EDJ-1083.



This "exploded" photograph shows the heart of the Double-D. Stock passing under constant pressure between two rotating and two stationary discs receives true two-pass refining . . . double effect

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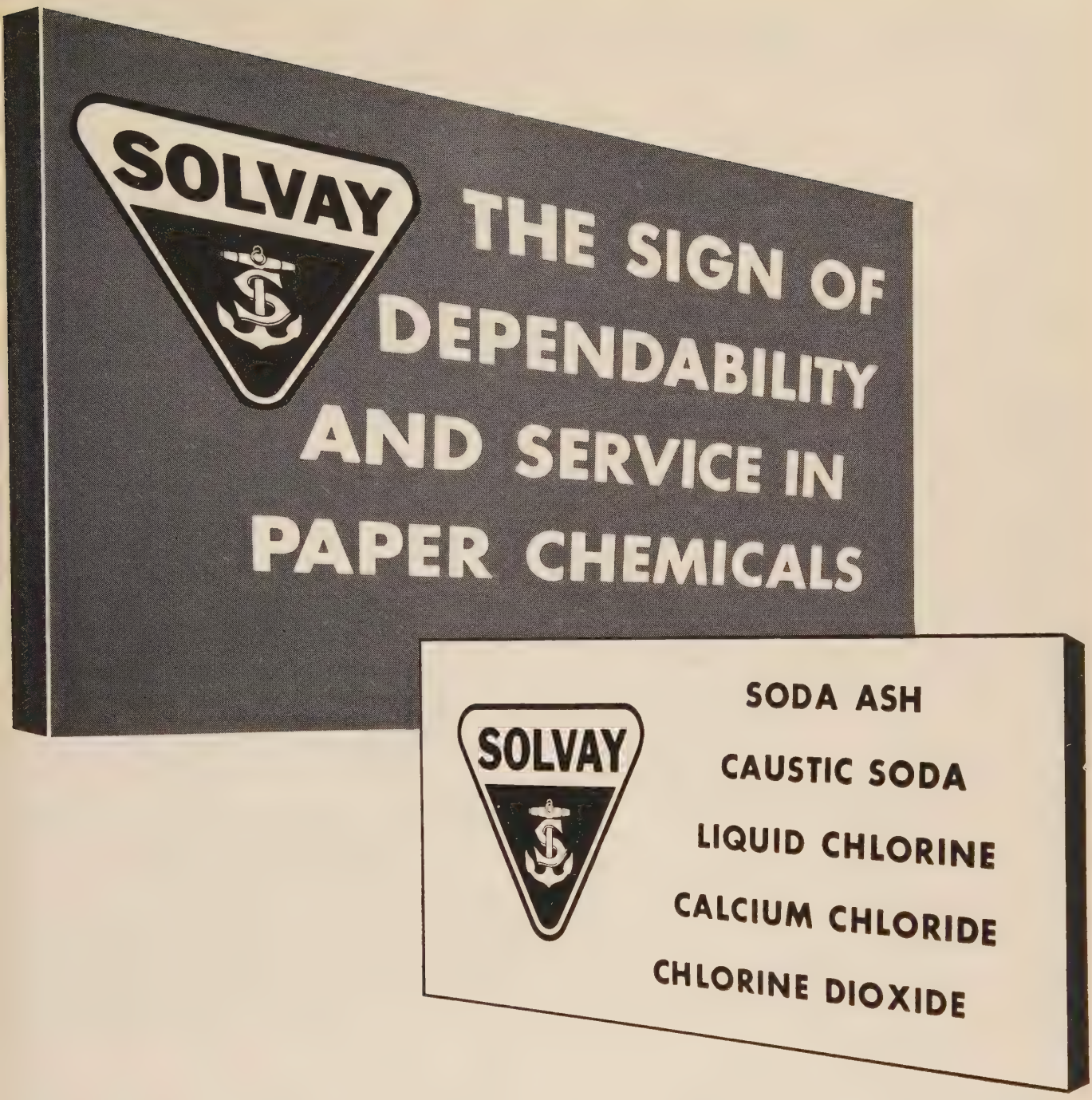
Table J. Reproducibility of Tear Factor at 50°S.-R. Based on the British Method of Sheetmaking

Beater	*Extra strong unbleached sulphite*	*Kraft*	*Extra strong bleached sulphite*	*L & S sulphate*	*E.B. sulphite*	*Strong bleached sulphite*	*Soft bleached sulphite*	*E.B. sulphate*	*Bleached aspen*	*Rayon*
Helsingfors	150	220	145	220	155	138	94	155	91	95
Lampén	140	200	150	225	145	125	80	165	95	95
	135	210	146	220	143	125	85	165	90	100
Av.	142	210	147	222	148	129	86	162	92	97
Oslo Lampén	140	210	145	205	148	136	100	165	. . .	115
	145	220	135	207	150	134	90	170	. . .	110
	140	200	143	215	155	130	100	155	. . .	112
Av.	142	210	144	209	151	133	97	163	. . .	112
Oslo PFI	157	240	167	260	167	151	125	203	100	158
	153	237	168	270	170	148	120	195	98	160
	155	235	175	280	165	143	125	200	97	167
Av.	155	237	170	270	167	147	123	199	98	162
Korsnäs Valley[a]	70	95	70	100	80	62	45	77	40	68
	68	95	72	100	85	60	48	80	43	60
	67	98	70	101	78	56	48	82	40	63
	75									
Av.	70	96	71	100	81	59	47	80	41	64
Skönsmon B & S			197							
	180	270	202	290	210	180	135	230	95	195
	185	265	190	260	210	175	125	240	95	190
	194	265	195	300	205	180	135	230	95	195
			205							
Av.	186	267	198	283	208	178	132	233	95	193
Helsingfors Valley	160	250	176	290	165	150	120	215	107	155
	180	260	175	280	170	155	120	205	97	154
	165	255	168	275	165	155	123	205	102	150
Av.	168	255	173	282	167	153	121	208	102	153
Helsingfors	165	240	175	265	180	157	125	205	101	163
N & W	165	250	175	260	190	164	118	210	95	160
	165	245	175	265	190	155	123	200	103	160
	160									
Av.	164	245	175	263	186	159	122	205	100	161
Aylesford	142	215	155	260	165	145	110	205	85	130
	142	217	160	255	155	145	110	205	80	140
	138	225	165	265	160	140	108	200	78	140
Av.	141	219	160	269	160	143	109	203	81	137
		95								
Korsnäs	80	100	67	120	80	65	60	107	55	83
B & S[a]	67	100	70	123	80	72	57	103	53	87
	67	100	80	130	80	70	55	106	50	78
Av.	71	99	72	124	80	69	57	105	53	83

[a] Lab's own method of sheetmaking.

Table K. Beating Times at 50°S.-R. for Three Repeated Beatings in the Different Beaters

		Bleached sulphites					*Unbleached sulphites*		*Sulphates*		
	Beating no.	*Extra strong*	*Strong*	*Soft*	*Aspen*	*Rayon*	*Extra strong*	*Easy bleached*	*Kraft*	*L & S*	*Easy bleached*
Aylesford beater, Reed	I	29	30	30	48	30	24	37	51	42	34
	II	29	30	29	50	32	26	39	51	44	35
	III	29	28	31	53	34	26	38	51	42	33
	Av.	29	29	30	50	32	25	38	51	43	34
Banning-Seybold beater,	I	21	17	12	10	14	20	25	47	39	18
Skönsmon	II	21	15	12	10	15	19	27	47	36	18
	III	21	15	12	10	15	18	25	45	37	17
	Av.	21	16	12	10	15	19	26	46	37	18
PFI mill, Oslo	I	92	69	83	85	122	86	121	310	317	172
	II	92	74	81	90	117	86	118	308	345	171
	III	92	71	79	87	119	86	120	314	333	167
	Av.	92	71	81	87	119	86	120	311	332	170
Lampén mill, Oslo	I	76	57	150	. . .	111	78	128	148	120	96
	II	74	65	60	. . .	99	85	128	158	116	80
	III	86	62	180	. . .	120	83	122	153	126	87
	Av.	79	61	130	. . .	110	82	126	153	120	88
Valley beater, Helsingfors	I	57	57	38	74	56	35	53	99	72	42
	II	58	56	38	76	56	36	54	102	77	41
	III	61	52	38	73	55	36	54	102	77	43
	Av.	59	55	38	74	56	36	54	101	75	42
Lampén mill, Helsingfors	I	60	64	75	139	120	56	64	134	104	52
	II	60	66	66	135	86	58	60	131	104	50
	III	62	68	66	138	100	54	60	132	104	52
	Av.	61	66	69	137	102	56	61	132	104	51
Noble & Wood beater,	I	29	27	20	50	23	29	43	47	42	26
Helsingfors	II	29	26	18	53	26	39	47	47	43	26
	III	29	27	18	50	26	34	43	48	42	27
	Av.	29	27	19	51	25	34	44	47	42	26
Valley beater, Korsnäs	I	63	51	28	92	63	40	39	66	66	48
	II	54	53	25	110	43	33	36	65	65	48
	III	47	52	29	101	53	38	39	66	65	49
	Av.	55	52	27	101	53	37	38	66	65	48
Banning & Seybold beater,	I	11	12	13	16	8	8	7	33	55	20
Korsnäs	II	11	12	14	11	9	8	7	21	28	19
	III	13	9	15	12	11	7	8	23	33	18
	Av.	12	11	14	13	9	8	7	25	39	19



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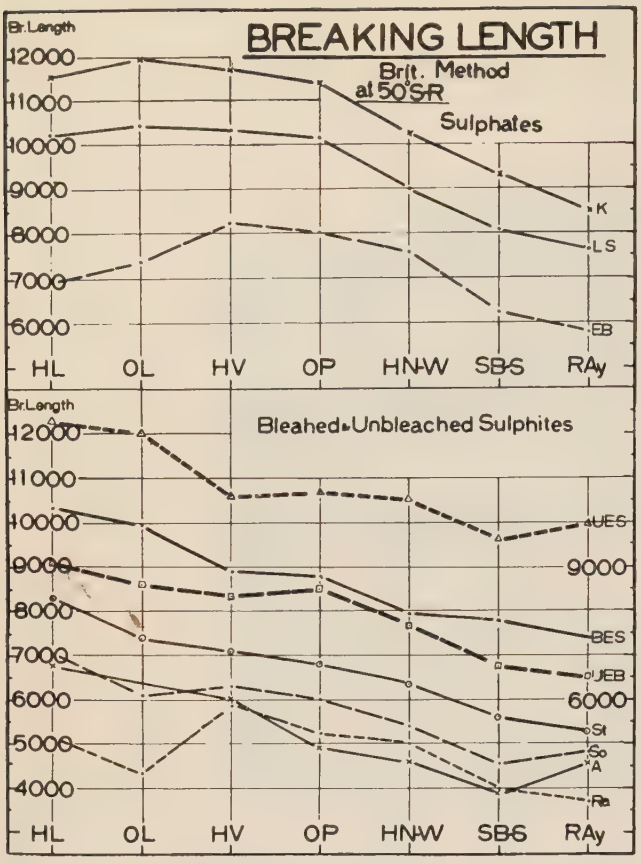

Fig. 18. The breaking length at 50°S.-R. of the different pulp qualties plotted with the various beaters as a basis

pulps are tested for strength. Since the present investigation reveals that the different laboratory beaters classify the strength properties of the pulps in the same order as the Aylesford beater and the Valley beater, the opinion is further supported, that it is possible on the basis of laboratory scale beatings to come to conclusions about the strength properties of the paper qualities which it is desired to make from different pulp qualities, and that the strength properties of a pulp in a carefully performed laboratory beating can be determined with an accuracy equal to that obtained when the beating is performed on the mill scale and the paper is made on the paper machine if there is such a thing as a standard mill beating. This, of course, is only valid in regard to the share, which the properties of the raw material, that is the pulp qualities, have in the properties of the machine made paper and not in regard to such properties, which have been brought about by the conditions on the paper machine.

Reproducibility. When one has to judge the value of a beating apparatus on laboratory as well as mill scale, the reproducibility of the beating results and the constancy of the apparatus are of prime importance. For a laboratory beater it is highly important that when a pulp sample is beaten repeatedly the same beatability and strength figures are obtained, regardless of whether the pulp sample is beaten several times in immediate succession or whether a fairly long time, even more than 10 years, elapses between the beatings. It is very difficult to control the constancy of the apparatus over a long time, since very few pulps, so called "check-pulps," remain constant, but change to a variable extent during storage.

In this investigation the pulps were carefully sampled and the dates fixed for beating in the various laboratories. The sheets were made by the standard method of the British Paper and Board Makers' Association (except in the case of Korsnäs) and all tested in the Centrallaboratorium Ab, Helsingfors.

Thus pulp sampling errors, aging effects on the pulps, sheetmaking, and sheet testing errors were all reduced to a minimum. If any variations occur between the triplicate beating results they can therefore be attributed mainly to the particular beating apparatus.

In Tables I, J, and K the figures for burst factor, breaking length, tear factor, and beating time taken from the individual curves at 50°S.-R. for the triplicate beatings are given. From these the reproducibility of the beaters can be judged. The assessment of reproducibility can vary according to the standard by which the judgment is made.

If *breaking length* is used as a measure, then the reproducibility is good, most of the beaters being able to repeat themselves well within the limits of ±3%.

If *burst factor* is employed as a criterion, then in some cases there seem large variations, especially with the rayon pulp, where most of the beaters show poor reproducibility.

The variations in the *tear* figures are less than those in the burst figures.

An attempt to control the constancy of the beating apparatus used in the investigation was made by repeating the beating of the strong bleached sulphite sample 1 year after the first beating. Due to the storage effect, the sample had changed, as is evident from Fig.

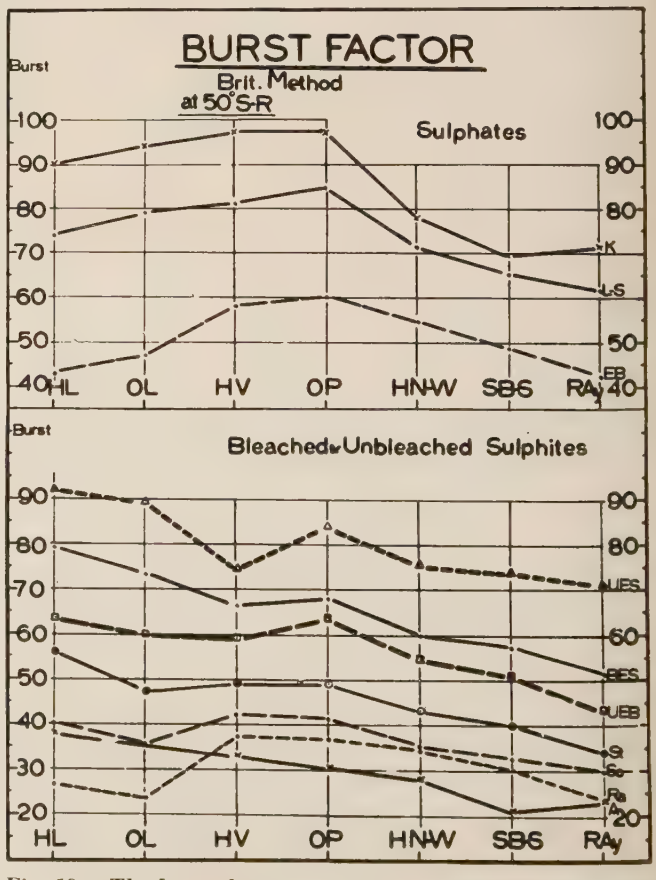

Fig. 19. The burst factor at 50°S.-R. of the different pulp qualities plotted with the various beaters as a basis

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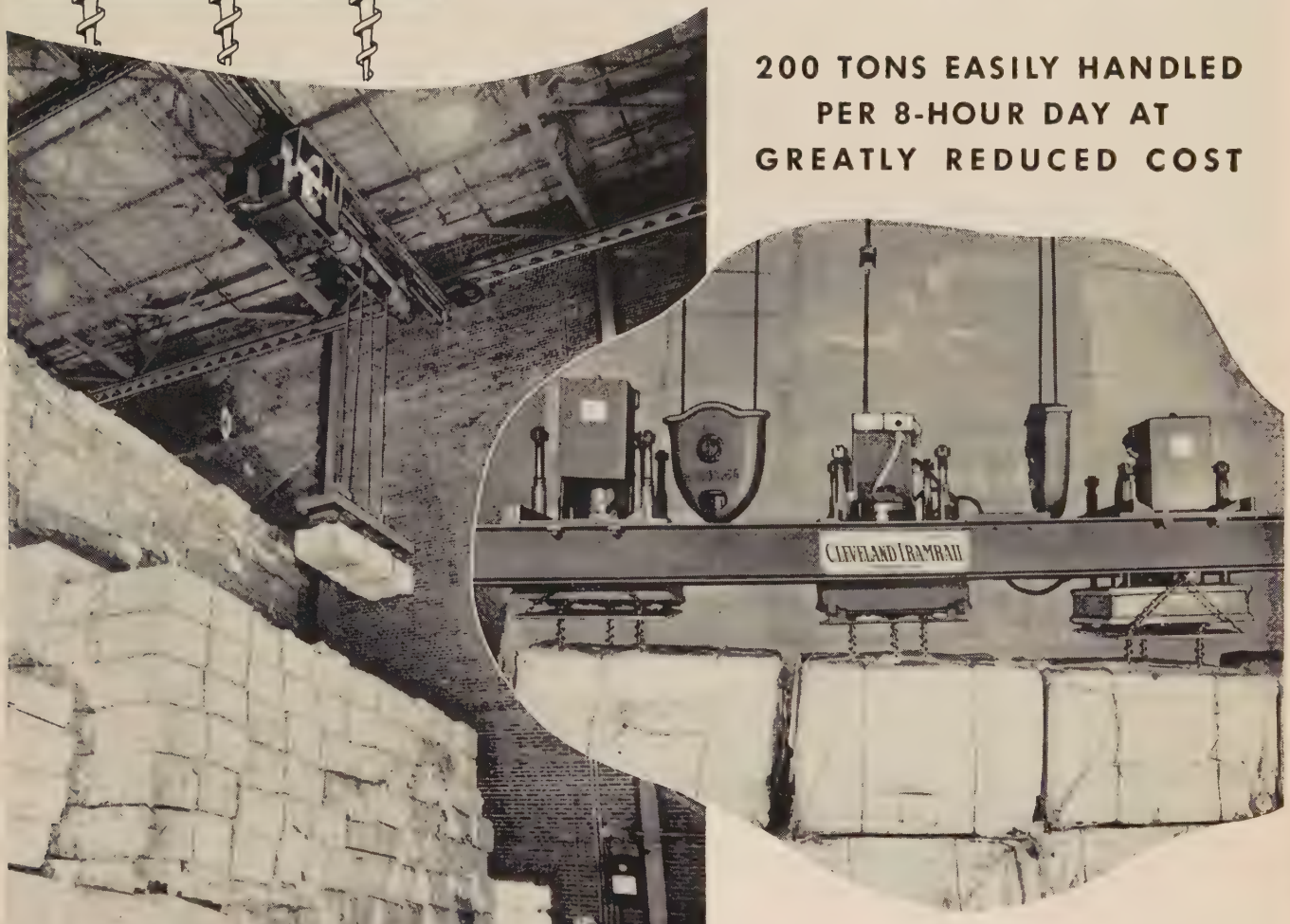

BALES PILED 35 FT. HIGH

The crane at left equipped with motor-operated screw grab above handles 3 bales at a time. All motions of crane and grab are controlled by operator in crane cab. This building has 5000 tons capacity and is 160'-0" x 50'-0" x 45'-0" truss height.

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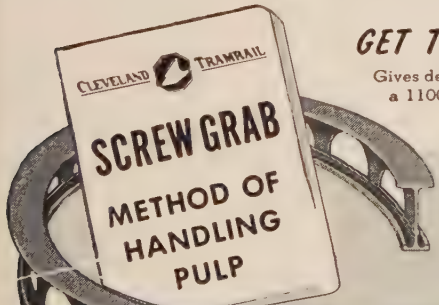

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Table V. Strength Properties After Beating in the Different Laboratory Beaters

Sheetmaking and testing of the sheets according to the British Paper & Board Makers' standard method; quality, bleached sulphite, extra strong

Beaters	Beating time	Wetness, S.-R.	Freeness, Canadian std., ml.	Break L, m.	Burst F, Mu	Burst F, Da	Tear F, M-M	Fold, sch.	Str., %	Vol. w., kg./dm.³	Opacity Scat. coeff.	Opacity C-R	Porosity B-U, sec.	Porosity G-H, sec.	Porosity Sch., cm.³/min.
Aylesford beater, Reed (RAy)	0 min.	18.0	631	4,275	28.9	28.0	240	90	2.6	0.623	408	0.83	2.5	8	1162
	8 min.	23.0	544	5,295	37.6	36.3	211	440	3.2	0.671	366	0.82	5.1	34	264
	16 min.	32.0	403	6,235	43.7	41.3	189	875	3.3	0.700	332	0.80	29	127	60
	24 min.	43.0	272	7,120	49.9	45.9	169	1115	3.6	0.743	295	0.76	95	590	15
	32 min.	55.0	176	7,600	52.1	47.5	154	1320	3.8	0.760	257	0.73	495	2805	4
	40 min.	66.0	114	7,875	53.2	49.2	145	1405	3.6	0.811	225	0.69	1942	>3000	1.2
	48 min.	77.0	63	7,890	54.2	50.7	144	1545	3.5	0.818	203	0.67	3105	>3000	1.2
	29 min.	50.0	216	7,400	51.2	46.8	160	1235	3.7	0.753	273	0.74	328	1882	9
Banning Seybold beater, Skönsmon (SB-S)	0 min.	15.5	622	3,705	24.5	23.6	247	35	2.7	0.585	421	0.85	2	5	1715
	5 min.	21.0	497	5,850	43.0	40.3	229	845	3.4	0.645	345	0.81	4	20	442
	10 min.	29.5	373	6,915	51.6	47.8	218	1385	3.7	0.677	311	0.79	11	60	142
	20 min.	48.5	186	7,775	56.5	51.8	198	1520	3.7	0.709	271	0.75	58	276	33
	25 min.	60.0	102	7,920	58.4	52.5	190	1720	3.8	0.725	248	0.74	124	835	11
	21 min.	50.0	176	7,820	56.9	51.9	196	1525	3.7	0.711	268	0.75	66	343	30
PFI-mill, Oslo (OP)	0 sec.	15.0	685	3,190	19.1	19.2	217	15	2.5	0.571	458	0.85	2	5	2145
	30 sec.	21.5	553	6,895	50.1	47.2	200	1125	3.8	0.703	300	0.77	8	35	228
	75 sec.	40.5	320	8,550	63.4	59.6	178	1935	4.2	0.725	228	0.72	45	269	31
	105 sec.	57.5	220	8,995	70.2	63.5	165	2260	4.2	0.788	198	0.69	172	1411	8
	150 sec.	75.5	117	9,505	75.5	69.8	154	2915	4.3	0.832	149	0.59	485	>3000	4
	195 sec.	81.5	63	9,215	77.5	71.1	147	3345	4.1	0.861	128	0.54	403	>3000	12
	92 sec.	50.0	264	8,815	67.2	61.8	169	2100	4.2	0.760	211	0.70	116	909	18
Lampén mill, Oslo (OL)	45 min.	40.5	352	9,565	69.4	62.1	153	1805	3.7	0.817	188	0.69	73	466	20
	90 min.	53.5	225	10,090	74.4	66.8	141	2215	4.0	0.845	149	0.62	273	1594	7
	180 min.	67.0	123	10,035	77.3	68.3	142	2935	4.1	0.872	122	0.53	659	>3000	2
	240 min.	74.3	83	9,775	77.5	69.5	133	3530	4.0	0.907	101	0.50	446	>3000	2
	79 min.	50.0	258	9,915	73.0	65.6	144	2065	3.9	0.838	159	0.64	221	1299	10
Valley beater, Helsingfors (HV)	0 min.	12.0	696	2,960	18.2	18.1	240	15	2.4	0.576	438	0.85	1	3	3340
	20 min.	18.5	556	6,995	49.0	46.2	205	1300	3.0	0.693	306	0.78	7	34	238
	40 min.	33.0	344	8,500	61.9	56.0	184	1860	3.4	0.739	247	0.73	39	258	36
	60 min.	51.5	177	8,915	66.2	61.4	177	2130	3.6	0.777	208	0.70	194	1622	7
	90 min.	74.0	52	9,120	67.1	61.5	159	2720	3.4	0.822	168	0.64	224	>3000	4
	120 min.	83.0	15	9,190	67.0	60.3	138	2855	3.6	0.864	148	0.59	166	>3000	1.9
	59 min.	50.0	189	8,885	65.9	61.0	177	2085	3.6	0.774	211	0.70	183	1525	9
Lampén mill, Helsingfors (HL)	0 min.	12.5	714	2,670	15.0	15.0	246	10	2.0	0.584	464	0.85	1	3	3365
	20 min.	20.0	521	8,955	64.2	57.7	177	1490	3.4	0.788	205	0.69	14	76	113
	40 min.	34.0	319	10,155	73.8	65.2	161	2110	3.9	0.840	158	0.62	72	693	16
	60 min.	50.0	176	10,360	78.7	69.5	148	2600	3.9	0.877	128	0.55	176	>3000	5
	90 min.	66.5	78	10,335	79.4	70.3	140	3275	4.1	0.903	105	0.50	212	>3000	14
	180 min.	83.0	20	10,085	78.2	69.9	129	4175	3.9	0.931	86	0.45	134	>3000	15
	61 min.	50.0	176	10,360	78.7	69.5	148	2610	3.9	0.877	128	0.55	165	3000	6
Noble & Wood beater, Helsingfors (HN-W)	0 min.	14.0	660	3,700	25.0	24.7	263	40	2.7	0.577	435	0.84	2	4	2330
	10 min.	21.5	504	6,645	47.8	44.4	213	1250	3.2	0.669	322	0.80	8	34	211
	20 min.	36.0	302	7,615	57.1	52.5	189	1680	3.6	0.711	274	0.76	50	240	32
	30 min.	51.5	164	8,040	59.5	55.1	172	1840	3.7	0.751	235	0.73	164	1141	8
	60 min.	75.5	44	8,105	61.0	57.6	151	2460	3.8	0.819	158	0.63	300	>3000	4
	75 min.	82.0	21	8,355	61.6	56.3	142	3030	3.6	0.838	141	0.57	148	>3000	1.8
	29 min.	50.0	179	7,985	59.3	54.8	174	1815	3.7	0.747	239	0.73	164	1141	8

Table VI. Strength Properties After Beating in the Different Laboratory Beaters

Sheetmaking and testing of the sheets according to the British Paper & Board Makers' standard method; quality, bleached sulphite, strong

Beaters	Beating time	Wetness, S-R	Freeness, Canadian std. ml.	Break L, m.	Burst F, Mu	Burst F, Da	Tear F, M-M	Tear Sch.	Str., %	Vol. w., kg./dm.³	Opacity Scatt. coeff.	Opacity C-R	Porosity B-U, sec.	Porosity G-H, sec.	Porosity Sch., cm.³/min.
Aylesford beater, Reed (RAy)	0 min.	17.0	655	2440	14.4	14.3	172	4	1.9	0.581	514	0.89	1.9	6	3960
	8 min.	23.0	535	3700	23.8	22.9	179	30	2.9	0.643	440	0.87	3.5	19	484
	16 min.	31.0	410	4360	28.8	27.3	168	70	3.2	0.678	415	0.85	9.3	87	111
	24 min.	43.0	270	5070	32.3	31.5	150	135	3.4	0.706	379	0.85	37	157	55
	32 min.	56.0	170	5450	34.2	33.7	137	185	3.4	0.740	340	0.83	75	459	22
	40 min.	67.0	102	5690	35.4	34.3	127	300	3.3	0.770	301	0.78	175	1621	8
	48 min.	77.0	60	5820	35.5	34.7	114	255	3.2	0.790	266	0.75	432	>3000	6
	29 min.	50.0	216	5275	33.3	32.7	143	162	3.4	0.724	358	0.84	57	320	37
Banning Seybold beater, Skönsmon (SB-S)	0 min.	16.0	630	2775	17.0	16.1	206	10	2.4	0.569	503	0.85	1.9	3	3240
	5 min.	22.0	467	4315	29.9	28.5	195	98	2.9	0.638	426	0.82	4.6	26	347
	10 min.	37.0	340	5235	36.6	33.9	190	263	3.5	0.659	398	0.81	10.9	48	170
	20 min.	61.0	140	5935	41.6	39.8	171	512	3.4	0.693	344	0.80	33	162	56
	16 min.	50.0	232	5600	39.3	37.1	180	365	3.4	0.677	369	0.80	22.9	110	108
PFI mill, Oslo (OP)	0 sec.	15.0	685	2080	11.0	11.7	152	3	2.5	0.555	542	0.88	1.7	2.3	4020
	15 sec.	19.0	590	4080	25.5	25.0	182	43	3.6	0.657	413	0.83	4.0	16.8	534
	45 sec.	34.0	420	6120	40.8	38.7	155	458	4.4	0.726	312	0.77	16	90.8	106
	85 sec.	58.0	220	7165	50.3	47.3	145	1015	4.9	0.779	237	0.72	99	>3000	17
	120 sec.	72.0	120	7865	56.8	51.9	140	1410	5.2	0.816	188	0.68	459	>3000	5
	150 sec.	79.0	75	7845	58.1	54.4	130	1703	5.6	0.842	156	0.60	647	>3000	3.5
	71 sec.	50.0	287	6817	47.1	44.4	149	817	4.7	0.761	262	0.74	71	478	47
Lampén mill, Oslo (OL)	15 min.	32.0	435	6370	38.2	37.0	148	307	3.2	0.760	283	0.76	12	62	174
	45 min.	47.0	285	7285	46.4	43.0	134	573	3.3	0.820	217	0.70	68	315	25
	120 min.	61.0	155	7805	51.5	47.7	129	1070	3.4	0.850	176	0.68	166	1257	11
	180 min.	65.0	130	7870	52.4	48.0	125	1047	3.4	0.865	160	0.65	150	1980	7
	61 min.	50.0	257	7383	47.8	44.0	133	667	3.3	0.826	208	0.70	89	517	22
Valley beater, Helsingfors (HV)	0 min.	12.5	670	2345	12.8	13.0	182	4	2.3	0.563	537	0.87	1.7	2	4820
	20 min.	20.5	527	5405	34.2	32.9	175	135	3.0	0.673	376	0.82	6.3	9	257
	45 min.	42.0	255	6940	45.3	42.5	158	830	3.3	0.720	295	0.78	39	209	42
	70 min.	61.0	100	7340	50.8	46.6	145	1050	3.5	0.759	257	0.75	199	1307	8
	90 min.	72.5	48	7255	50.8	46.0	137	1400	3.5	0.774	226	0.72	420	>3000	5
	120 min.	82.0	14	7055	48.9	45.1	126	1135	3.4	0.815	184	0.68	460	>3000	2.9
	55 min.	50.0	190	7100	47.8	44.2	152	1075	3.4	0.736	279	0.77	106	671	28
Lampén mill, Helsingfors (HL)	0 min.	11.5	715	1805	8.5	9.2	138	1	1.7	0.543	530	0.87	1.4	1	8180
	20 min.	23.5	450	7215	45.5	42.1	150	625	3.0	0.749	240	0.71	12	72	120
	40 min.	39.0	235	8170	52.5	49.8	135	945	3.4	0.850	178	0.67	97	550	20
	90 min.	60.0	88	8555	56.8	53.0	123	1115	3.5	0.885	132	0.56	263	>3000	5
	180 min.	73.0	40	7810	55.5	52.5	119	1300	3.7	0.917	96	0.50	368	>3000	4
	66 min.	50.0	158	8385	54.8	51.5	129	1000	3.5	0.868	154	0.61	184	>3000	12
Noble & Wood beater, Helsingfors (HN-W)	0 min.	16.0	610	2865	17.5	17.7	207	10	2.8	0.583	486	0.86	2.2	3	1224
	10 min.	26.0	465	5230	33.9	33.0	177	175	3.1	0.671	387	0.83	7.5	34	246
	20 min.	41.5	275	6145	41.7	39.2	165	630	3.4	0.711	333	0.81	29	154	60
	30 min.	54.5	155	6470	43.2	41.6	156	590	3.5	0.728	302	0.78	71	456	22
	40 min.	65.5	85	6490	44.7	42.4	146	660	3.5	0.753	273	0.75	261	2278	7
	60 min.	77.5	37	6260	43.6	41.8	131	810	3.4	0.788	220	0.72	468	>3000	4
	27 min.	50.0	199	6365	42.8	40.8	158	600	3.5	0.722	313	0.79	56	351	35

News about National's Vinyl Solutions and Emulsions

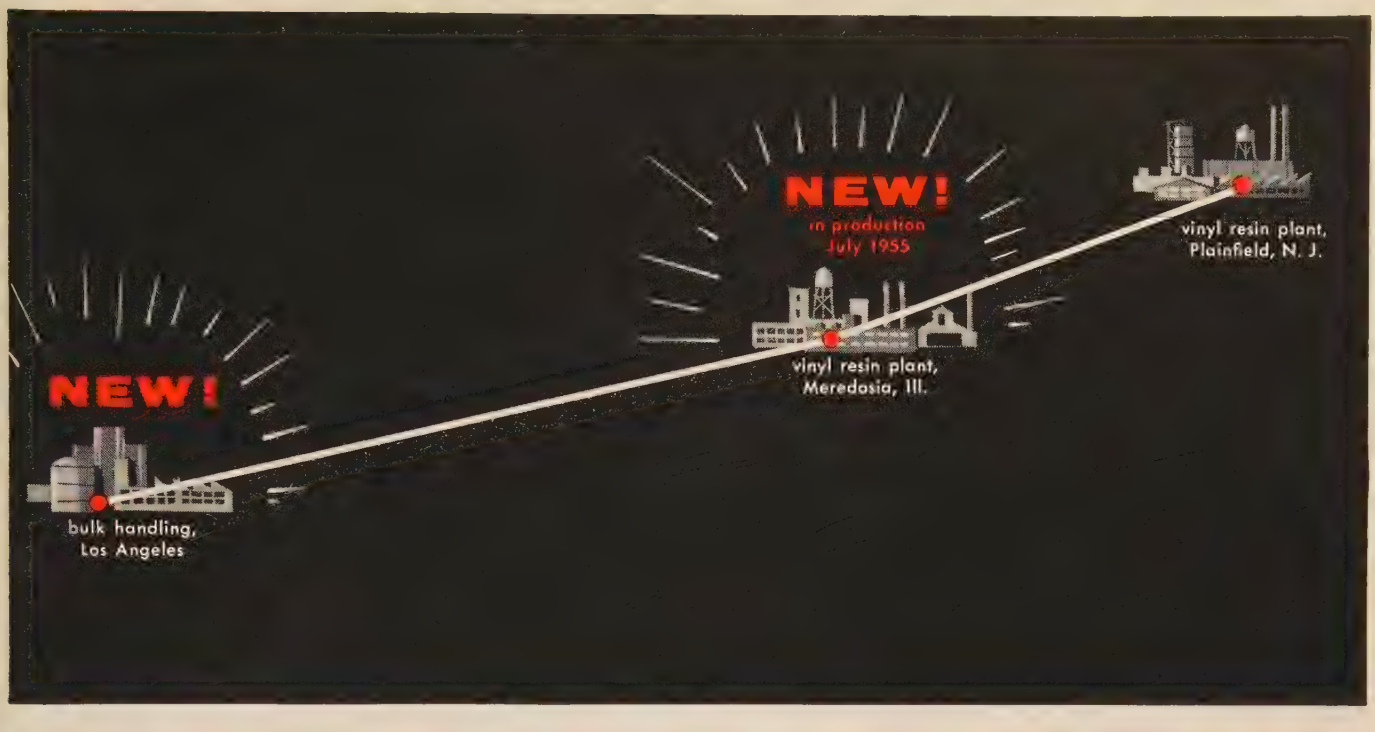

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Table VII. Strength Properties After Beating in the Different Laboratory Beaters

Sheetmaking and testing of the sheets according to the British Paper & Board Makers' standard method; quality, bleached sulphite, soft

Beaters	Beating time	Wetness, S.-R.	Freeness, Canadian std. ml.	Break L, m.	Burst F, Mu	Burst F, Da	Tear F, M-M	Fold, Sch.	Str., %	Vol. w., kg./dm.³	Opacity Scatt. coeff.	Opacity C-R	Porosity B-U, sec.	Porosity G-H, sec.	Porosity Sch., cm.³/min.
Aylesford beater, Reed (RAy)	0 min.	16.0	671	1825	10.4	10.5	170	2	1.8	0.574	534	0.85	1.2	1	3740
	8 min.	23.0	535	3275	19.9	19.5	158	12	2.6	0.631	469	0.84	2.5	12	990
	16 min.	32.0	402	3995	24.9	24.5	134	22	2.7	0.676	432	0.82	8.9	43	180
	24 min.	42.0	282	4500	27.7	27.1	118	30	2.7	0.705	394	0.82	23	18	77
	32 min.	54.0	185	4980	29.7	28.1	108	45	2.7	0.732	369	0.80	58	212	16
	40 min.	64.0	121	5285	30.9	30.0	96	47	2.8	0.763	338	0.78	140	778	11
	48 min.	71.0	86	5430	32.5	31.0	89	50	2.7	0.783	293	0.76	318	2200	6
	30 min.	50.0	217	4800	29.0	27.8	111	40	2.7	0.723	379	0.81	46	180	36
Banning Seybold beater, Skönsmon (SB-S)	0 min.	16.0	640	1840	11.7	11.4	178	3	2.5	0.549	512	0.84	1.1	2	5080
	5 min.	22.5	450	3735	26.5	25.7	157	35	3.6	0.627	432	0.82	3.0	15	524
	10 min.	39.0	270	4460	31.3	30.0	135	55	3.8	0.661	399	0.82	10.1	60	155
	15 min.	67.0	130	4745	33.4	32.2	130	130	3.8	0.688	362	0.81	44	255	40
	12 min.	50.0	215	4575	32.1	30.9	133	85	3.8	0.672	378	0.82	24	137	109
PFI mill, Oslo (OP)	0 sec.	14.0	690	1480	8.0	8.2	134	0	1.4	0.520	579	0.86	1.2	2	12,120
	30 sec.	20.5	530	4310	29.4	28.1	147	40	3.2	0.650	400	0.82	3.0	12	677
	75 sec.	45.5	290	5865	40.9	38.5	123	185	3.6	0.713	326	0.77	19	27	94
	105 sec.	67.5	150	6435	45.7	42.4	117	385	3.9	0.745	179	0.74	67	437	32
	135 sec.	75.5	105	6850	47.2	44.4	109	550	3.7	0.775	238	0.71	151	1271	10
	165 sec.	81.5	65	7000	48.5	45.1	103	525	3.7	0.808	215	0.71	394	>3000	5
	81 sec.	50.0	262	6000	41.6	39.3	122	165	3.7	0.719	316	0.76	29	110	81
Lampén mill, Oslo (OL)	30 min.	40.0	320	5745	33.8	31.4	101	50	2.6	0.766	293	0.75	20	106	94
	60 min.	45.0	275	5995	35.1	33.5	97	53	2.8	0.783	271	0.74	20	105	72
	180 min.	52.5	210	6115	35.5	34.1	92	80	2.8	0.803	252	0.72	29	168	50
	130 min.	50.0	233	6045	35.2	33.9	95	70	2.8	0.796	260	0.73	26	147	57
Valley beater, Helsingfors (HV)	0 min.	12.5	692	1480	8.1	8.0	142	2	1.5	0.537	550	0.85	1.2	1	4080
	20 min.	22.0	470	5060	33.6	32.0	143	90	3.0	0.673	374	0.80	5.2	24.1	336
	35 min.	46.0	234	6245	41.5	38.0	123	205	3.0	0.721	318	0.76	28	129	48
	50 min.	66.5	100	6495	43.9	40.8	114	235	3.0	0.740	271	0.74	138	903	11
	70 min.	79.5	39	6440	43.2	39.6	111	250	2.9	0.781	232	0.70	392	>3000	5
	38 min.	50.0	208	6290	42.0	38.6	121	195	3.0	0.725	308	0.76	49	280	41
Lampén mill, Helsingfors (HL)	0 min.	11.5	721	1290	6.2	6.1	116	1	1.2	0.521	550	0.86	1.2	1	8040
	20 min.	28.5	361	6040	34.1	32.5	98	55	2.5	0.802	259	0.71	12	61	148
	40 min.	40.0	227	6860	39.1	36.6	91	110	2.6	0.833	220	0.69	53	336	29
	90 min.	57.0	128	7210	40.9	38.7	83	140	2.7	0.893	159	0.57	238	2138	8
	180 min.	78.0	316	7300	47.2	44.4	82	450	3.0	0.040	103	0.47	499	>3000	3.2
	69 min.	50.0	172	7065	40.2	37.8	87	100	2.7	0.868	184	0.62	162	1395	17
Noble & Wood beater, Helsingfors (HN-W)	0 min.	13.5	663	2030	11.9	12.0	172	3	2.1	0.559	485	0.85	1.2	1	5400
	10 min.	27.5	393	4790	30.8	29.9	138	53	3.1	0.680	383	0.81	7.3	29	263
	20 min.	53.5	154	5500	35.6	34.0	120	100	3.2	0.716	331	0.78	48	253	34
	30 min.	71.5	67	5815	37.3	35.7	108	110	3.4	0.763	265	0.74	179	1280	11
	40 min.	80.5	54	5945	37.9	36.6	97	160	3.0	0.784	221	0.71	357	>3000	5
	19 min.	50.0	184	5400	35.0	33.5	123	90	3.2	0.711	338	0.78	42.5	223	65

Table VIII. Strength Properties after Beating in the Different Laboratory Beaters

Sheetmaking and testing of the sheets according to the British Paper & Board Makers' standard method; quality, bleached sulphite, aspen

Beaters	Beating time	Wetness, S.-R.	Freeness, Canadian std. ml.	Break L, m.	Burst F, Mu	Burst F, Da	Tear F, M-M	Fold, Sch.	Str., %	Vol. w., kg./dm.³	Opacity Scatt. coeff.	Opacity C-R	Porosity B-U, sec.	Porosity G-H, sec.	Porosity Sch., cm.³/min.
Aylesford beater, Reed (RAy)	0 min.	21.0	570	1710	4.8	7.2	44	1	0.9	0.587	655	0.88	1.9	7	1220
	12 min.	27.0	477	2785	10.9	12.5	65	2	1.7	0.664	583	0.86	3.4	18	500
	24 min.	34.0	375	3455	15.8	16.6	81	5	1.9	0.704	552	0.85	8.1	44	196
	36 min.	41.0	292	3985	19.3	19.7	82	10	2.3	0.739	501	0.84	19	100	63
	48 min.	47.0	234	4410	22.3	22.6	81	15	2.4	0.774	453	0.83	42	238	38
	60 min.	54.0	304	4730	24.2	23.5	79	15	2.5	0.795	407	0.82	90	640	17
	72 min.	60.0	392	4895	25.7	25.5	76	20	2.6	0.823	366	0.78	164	807	12
	50 min.	50.0	264	4550	23.1	23.0	80	15	2.4	0.783	433	0.83	63	288	29
Banning Seybold beater, Skönsmon (SB-S)	0 min.	20.0	530	1870	6.1	8.1	55	1	1.2	0.590	652	0.88	1.9	7	116
	5 min.	32.0	360	3155	16.0	16.3	83	5	2.1	0.662	569	0.86	5.8	26	299
	10 min.	50.0	180	3870	20.7	21.5	95	10	2.4	0.693	512	0.85	13	72	126
	15 min.	62.0	105	4315	24.4	25.2	100	20	2.9	0.727	487	0.84	28	137	56
	10 min.	50.0	180	3870	20.7	21.5	95	10	2.4	0.693	512	0.85	13	73	126
PFI mill, Oslo (OP)	0 sec.	16.0	610	995	3.1	3.7	27	0	0.5	0.552	714	0.90	1.5	4	2400
	30 sec.	26.5	428	3145	15.1	16.7	75	5	2.3	0.677	537	0.87	4.0	20	410
	60 sec.	40.0	297	4300	24.2	24.5	94	15	3.0	0.734	454	0.85	13	65	127
	90 sec.	51.0	230	4955	30.5	30.6	98	40	3.3	0.775	398	0.83	37	186	41
	120 sec.	57.5	218	4925	32.2	31.5	103	50	3.3	0.796	370	0.82	49	309	29
	180 sec.	74.0	278	5450	36.9	36.4	112	130	3.7	0.839	292	0.75	229	1773	6
	87 sec.	50.0	236	4905	29.9	30.0	97	40	3.3	0.771	304	0.83	35	175	49
Lampén mill, (OL)	15 min.	20.5	510	2730	10.3	12.0	56	1	1.3	0.646	539	0.88	22	2	1090
	45 min.	28.0	410	3885	18.1	19.3	77	5	1.9	0.712	495	0.85	5.1	6	352
	90 min.	30.5	395	4220	20.4	20.8	78	10	2.1	0.727	436	0.84	7.8	10	209
	180 min.	33.0	355	4340	22.6	22.8	88	10	2.3	0.743	419	0.84	8.4	11	195
Valley beater, Helsingfors (HV)	0 min.	15.5	594	1515	4.1	5.6	41	0	0.8	0.561	670	0.92	1.3	4	2560
	20 min.	21.0	473	3370	13.9	15.3	83	4	1.9	0.652	546	0.89	3.4	4	458
	40 min.	30.0	351	4710	23.0	23.7	95	15	2.4	0.713	471	0.87	11	15	156
	60 min.	42.0	217	5775	30.2	29.5	104	40	2.9	0.750	404	0.85	30	48	49
	90 min.	59.0	120	6335	35.7	35.7	97	75	3.2	0.796	329	0.82	161	305	10
	120 min.	72.0	201	6520	37.5	37.9	85	135	3.3	0.830	263	0.77	748	1736	4
	150 min.	78.5	420	6615	38.5	37.6	75	140	3.6	0.856	212	0.72	1341	>3000	1.4
	74 min.	50.0	171	6035	32.9	32.4	100	50	3.0	0.772	369	0.84	92	169	31
Lampén mill, Helsingfors (HL)	0 min.	15.0	623	1170	2.8	4.0	32	0	0.4	0.537	705	0.91	1.3	31	3290
	20 min.	22.0	470	4490	19.1	20.0	85	7	2.0	0.717	436	0.85	4.5	23	367
	40 min.	28.0	372	5200	26.0	25.9	96	20	2.5	0.770	378	0.82	8.7	45	198
	60 min.	31.5	324	5860	28.9	28.1	100	25	2.4	0.788	354	0.81	15	83	109
	120 min.	41.5	221	6530	34.8	33.4	96	70	2.8	0.836	298	0.76	31	165	57
	180 min.	70.0	382	7440	45.3	42.8	88	360	3.9	0.919	155	0.65	669	>3000	4
	137 min.	50.0	268	6785	37.8	36.2	94	150	3.1	0.860	256	0.73	218	320	41
Noble & Wood beater, Helsingfors (HN-W)	0 min.	18.0	539	2000	6.0	8.5	48	1	1.1	0.586	667	0.90	1.7	5	2170
	10 min.	22.5	451	3000	12.0	14.0	72	2	1.7	0.633	599	0.89	3.3	17	515
	20 min.	28.0	365	3725	17.4	18.6	85	6	2.1	0.671	545	0.88	6.1	30	267
	40 min.	42.5	222	4695	25.2	25.5	98	20	2.7	0.715	463	0.87	21	111	84
	60 min.	56.5	147	5420	29.6	29.3	100	35	3.1	0.752	395	0.85	55	303	28
	90 min.	70.0	251	5900	34.1	33.0	94	70	3.5	0.790	338	0.83	156	1439	9
	51 min.	50.0	181	5065	27.5	27.6	100	30	2.9	0.735	426	0.86	39	215	54

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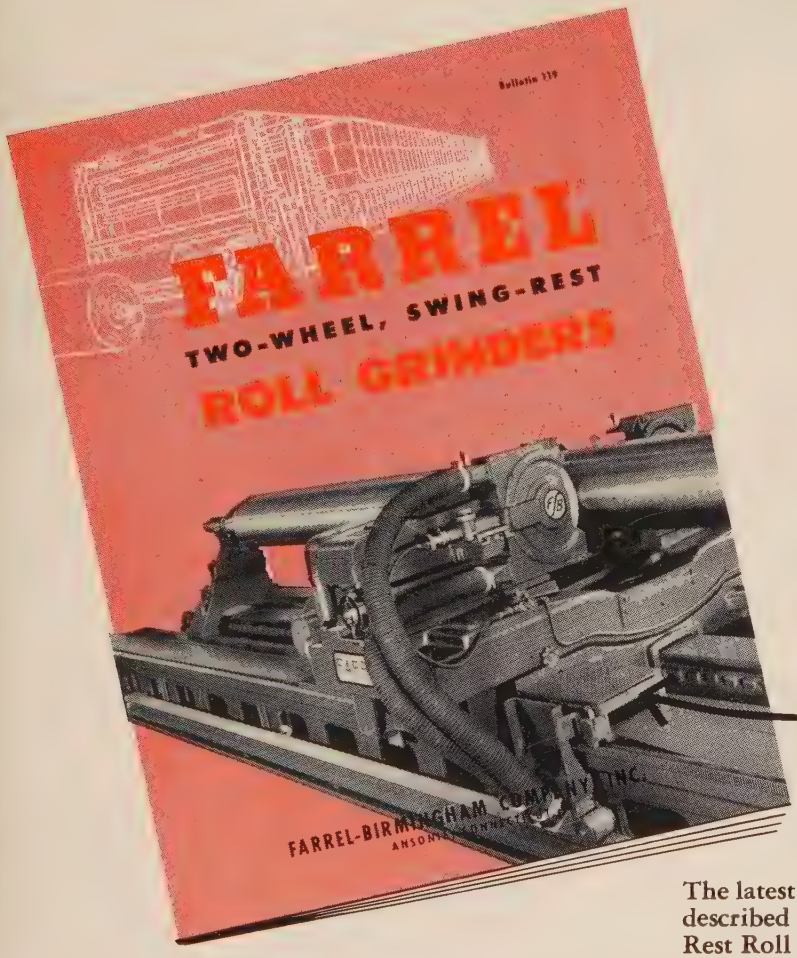

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Table IX. Strength Properties After Beating in the Different Laboratory Beaters

Sheetmaking and testing of the sheets according to the British Paper and Board Makers' standard method; quality, bleached sulphite, rayon

Beaters	Beating time	Wetness, S.-R.	Freeness, Canadian std. ml.	Break L, m.	Burst F, Mu	Burst F, Da	Tear F, M-M	Fold, Sch.	Str., %	Vol. w., kg./dm.³	Opacity Scatt. C-R	Opacity C-R	Porosity B-U, sec.	Porosity G-H, sec.	Porosity Sch., cm.³/min.
Aylesford beater, Reed (RAy)	0 min.	18.0	646	1415	9.1	9.5	156	2	1.9	0.524	625	0.91	1.2	3	4300
	8 min.	22.0	560	2215	14.6	14.7	191	6	2.7	0.578	590	0.88	1.7	9	1247
	16 min.	29.0	440	2805	19.1	18.9	172	15	3.2	0.583	565	0.87	3.4	20	418
	24 min.	39.0	314	3345	21.3	21.7	155	20	3.2	0.653	547	0.87	8.7	44	183
	32 min.	50.0	212	3655	23.6	23.2	134	25	3.4	0.676	526	0.86	18	74	112
	40 min.	60.0	142	3870	25.1	24.0	127	30	3.3	0.701	529	0.85	38	167	47
	48 min.	70.0	91	4090	25.6	25.2	111	30	3.3	0.718	492	0.84	70	505	19
	32 min.	50.0	212	3655	23.6	23.2	134	25	3.4	0.676	526	0.86	18	74	112
Banning Seybold beater, Skönsmon (SB-S)	0 min.	13.5	665	1390	8.7	8.6	164	2	1.8	0.513	602	0.86	1.2	2	4616
	5 min.	21.0	515	2880	19.6	19.6	220	20	3.3	0.580	523	0.83	2.1	8	1096
	10 min.	37.0	300	3585	26.7	25.7	204	45	3.7	0.615	506	0.84	4.7	22	372
	20 min.	64.0	90	4490	33.7	31.9	175	150	4.0	0.660	465	0.83	26	139	63
	15 min.	50.0	198	4035	30.1	28.7	190	115	3.8	0.636	486	0.84	15	79	222
PFI mill, Oslo (OP)	0 sec.	14.0	707	1075	6.1	6.4	108	0	1.5	0.486	625	0.90	1.1	1	5880
	30 sec.	18.0	588	2930	18.4	19.0	199	15	2.9	0.603	492	0.87	1.8	6	1388
	90 sec.	37.0	383	4890	32.6	31.8	169	125	3.6	0.674	400	0.85	6.4	34	253
	135 sec.	57.5	237	5390	38.3	38.0	159	320	3.7	0.713	365	0.83	19	89	96
	165 sec.	65.5	181	5550	39.4	38.5	153	323	3.9	0.731	359	0.83	33	179	48
	210 sec.	75.5	112	5770	42.3	41.0	144	450	3.9	0.757	323	0.82	76	406	21
	119 sec.	50.0	290	5235	36.3	35.8	163	250	3.7	0.699	378	0.84	15	69	152
Lampén mill, Oslo (OLa)	15 min.	30.0	433	3730	19.6	19.3	118	10	2.0	0.698	433	0.84	2.8	11	708
	30 min.	42.0	310	4325	23.3	23.1	114	20	2.5	0.748	394	0.83	6.5	43	211
	120 min.	51.5	235	4360	23.9	23.9	111	20	2.5	0.768	371	0.82	11	56	153
	180 min.	52.0	228	4295	23.7	23.6	113	20	2.5	0.769	371	0.82	10	58	153
	110 min.	50.0	245	4360	23.8	23.8	112	20	2.5	0.765	374	0.82	10	54	161
Valley beater, Helsingfors (HV)	0 min.	13.0	692	935	5.5	4.9	112	0	1.0	0.483	631	0.89	1.0	1	8140
	20 min.	18.5	547	3560	21.1	21.4	195	25	2.4	0.603	501	0.87	2.1	9	981
	40 min.	35.0	326	5175	31.5	32.3	165	190	2.9	0.667	449	0.86	9.1	51	165
	60 min.	54.0	151	6010	38.8	38.0	150	335	3.2	0.708	398	0.83	40	234	36
	90 min.	72.5	46	6460	41.8	40.2	128	475	3.0	0.753	334	0.81	235	2010	6
	120 min.	81.0	30	6540	41.2	39.8	114	515	3.4	0.791	280	0.76	500	>3000	2.1
	56 min.	50.0	187	5865	37.1	36.8	153	250	3.1	0.699	409	0.84	34	196	63
Lampén mill, Helsingfors (HL)	0 min.	12.0	718	840	4.6	3.9	88	0	0.8	0.465	622	0.89	1.0	1	7600
	20 min.	22.5	449	4185	21.2	21.0	125	15	2.1	0.718	404	0.82	2.7	12	721
	60 min.	45.5	158	5030	25.5	24.5	103	27	2.3	0.811	348	0.80	22	130	74
	120 min.	52.5	144	5300	27.4	25.7	95	35	2.5	0.847	305	0.77	42	241	38
	180 min.	74.0	387	6915	38.9	37.0	80	263	3.3	0.949	137	0.57	550	>3000	1.5
	102 min.	50.0	149	5170	26.6	25.3	96	33	2.4	0.834	320	0.78	35	202	51
Noble & Wood beater, Helsingfors (HN-W)	0 min.	14.0	631	1475	8.6	9.1	167	2	1.8	0.509	628	0.81	1.2	2	4950
	10 min.	23.0	454	3775	24.2	23.9	193	43	3.0	0.609	502	0.87	2.9	14	618
	20 min.	42.0	251	4840	33.3	31.2	169	148	3.2	0.658	456	0.86	14	78	108
	30 min.	58.5	126	5145	35.3	34.0	151	190	3.2	0.693	418	0.84	51	339	28
	40 min.	69.0	65	5475	36.4	35.2	138	252	3.4	0.721	376	0.83	161	1025	10
	60 min.	80.0	39	5660	37.2	35.4	120	280	3.6	0.753	319	0.81	507	>3000	5
	25 min.	50.0	189	5000	34.3	32.6	158	165	3.2	0.675	437	0.85	32	208	68

Table X. Strength Properties After Beating in the Different Laboratory Beaters

Sheetmaking and testing of the sheets according to the British Paper & Board Makers' standard method; quality, unbleached sulphite, extra strong

Beaters	Beating time	Wetness, S.-R.	Freeness, Canadian std. ml.	Break I, Mu	Burst F, Da	Burst F, M-M	Tear F, Sch.	Fold, Sch.	Str., %	Vol. w., kg./dm.³	Opacity Scatt. coeff.	Opacity C-R	Porosity B-U, sec.	Porosity G-H, sec.	Porosity Sch., cm.³/min.
Aylesford beater Reed (RAy)	0 min.	18.0	648	6,425	42.1	39.1	203	495	2.4	0.639	316	0.84	2	7	1188
	8 min.	23.0	537	8,225	56.5	52.8	186	...	3.3	0.692	264	0.81	12	63	138
	16 min.	34.0	380	9,335	66.0	59.4	167	1485	3.6	0.738	221	0.77	69	664	25
	20 min.	40.0	299	9,670	68.2	61.4	154	...	3.7	0.760	200	0.75	193	1154	13
	24 min.	48.0	234	9,895	70.3	63.2	144	1665	3.8	0.771	180	0.73	490	3000	8
	28 min.	55.0	180	10,055	72.0	64.1	136	...	3.9	0.798	159	0.70	1217	3000	6
	32 min.	62.0	136	10,205	71.8	63.5	132	...	4.0	0.817	134	0.66	...	3000	6
	36 min.	69.0	95	10,225	70.3	63.5	126	2555	4.1	0.830	116	0.60	1866	3000	5
	25 min.	50.0	219	9,950	70.8	63.5	142	1700	3.8	0.779	174	0.72	720	3000	7
Banning Seybold beater, Skönsmon (SB-S)	0 min.	15.0	649	6,875	49.9	43.5	206	835	3.2	0.648	288	0.81	3.0	12	720
	5 min.	21.0	547	8,365	60.0	54.5	197	...	3.7	0.678	258	0.79	6.0	29	274
	10 min.	28.5	404	9,125	68.9	60.2	190	1715	3.9	0.706	240	0.76	19	102	88
	20 min.	53.0	218	9,685	74.9	66.3	188	...	4.4	0.736	213	0.73	97	440	23
	30 min.	74.5	72	9,655	76.1	67.6	173	2420	4.2	0.754	171	0.66	519	3000	8
	19 min.	50.0	241	9,600	73.9	65.6	183	2000	4.3	0.732	216	0.73	87	399	31
PFI mill, Oslo (OP)	0 sec.	20.5	535	6,930	47.9	44.9	196	725	2.9	0.638	309	0.85	3	13	616
	60 sec.	37.5	327	10,395	76.7	66.5	161	2405	4.2	0.733	190	0.74	85	513	25
	105 sec.	61.0	155	10,900	80.9	72.8	149	2900	4.4	0.781	138	0.67	570	3000	6
	135 sec.	75.5	97	10,905	85.7	75.5	139	3620	4.6	0.808	104	0.58	903	3000	6
	180 sec.	81.5	60	10,900	84.3	74.4	129	4780	4.6	0.844	81	0.48	727	3000	4
	84 sec.	50.0	236	10,650	79.1	69.9	155	2635	4.3	0.759	162	0.70	343	2140	15
Lampén mill, Oslo (OL)	30 min.	31.5	393	11,305	83.0	73.7	158	2190	3.9	0.760	172	0.72	49	234	39
	60 min.	43.0	293	11,815	87.0	76.0	151	2830	4.0	0.778	143	0.68	172	1345	11
	120 min.	62.0	173	12,360	92.6	79.9	106	4235	4.4	0.826	103	0.55	690	3000	7
	180 min.	74.0	112	12,335	93.9	79.4	127	5255	4.4	0.850	75	0.47	674	3000	4
	82 min.	50.0	249	12,000	89.1	77.4	145	3265	4.1	0.796	128	0.63	360	2600	9
Valley beater, Helsingfors (HV)	0 min.	15.0	682	5,790	34.7	33.2	217	340	2.2	0.607	328	0.85	1.5	4.5	1755
	20 min.	27.5	446	10,140	69.6	62.7	180	1960	3.1	0.708	217	0.77	13	85	74
	30 min.	41.5	300	10,490	73.1	65.7	166	...	3.2	0.729	179	0.74	159	945	13
	40 min.	57.0	171	10,640	75.1	66.8	160	2965	3.4	0.758	158	0.71	341	3000	
	60 min.	74.5	55	10,495	73.9	65.0	149	3650	3.5	0.799	131	0.68	1560	3000	8
	90 min.	85.0	7	10,235	70.4	60.7	129	3805	3.5	0.835	112	0.64	1835	3000	6
	36 min.	50.0	229	10,565	74.2	66.3	163	2750	3.3	0.745	167	0.72	260	2400	9
Lampén mill, Helsingfors (HL)	0 min.	13.0	701	5,025	28.2	27.9	218	85	1.9	0.591	330	0.86	1.2	3.0	2835
	20 min.	21.5	523	11,035	80.5	71.9	168	2680	4.0	0.752	162	0.72	9	19	202
	40 min.	40.0	326	12,055	88.6	78.6	148	3565	4.0	0.790	124	0.66	155	297	12
	60 min.	53.5	180	12,415	93.2	83.4	198	...	3.9	0.811	105	0.59	349	3000	7
	90 min.	70.0	88	12,415	94.5	82.2	141	3175	4.2	0.833	91	0.56	620	3000	5
	150 min.	81.0	28	12,015	91.7	78.6	129	2915	4.2	0.857	75	0.49	1230	3000	6
	55 min.	50.0	218	12,300	91.9	82.2	141	3415	3.9	0.806	110	0.61	300	2700	8
Noble & Wood beater, Helsingfors (HN-W)	0 min.	14.5	681	6,010	37.9	36.1	226	440	2.3	0.616	313	0.85	1.5	3.3	2515
	10 min.	22.0	532	9,135	63.6	58.4	183	...	3.2	0.687	236	0.78	17	78	109
	20 min.	34.0	387	10,105	71.7	69.1	174	1785	3.6	0.713	205	0.76	93	523	22
	30 min.	44.5	271	10,495	74.7	67.1	165	...	3.7	0.728	185	0.75	170	1033	14
	40 min.	56.5	174	10,580	75.6	68.1	159	...	3.9	0.756	165	0.72	353	3000	9
	75 min.	79.5	32	10,215	70.2	63.0	135	2210	3.9	0.802	132	0.68	1176	3000	6
	34 min.	50.0	227	10,525	75.5	67.6	162	1925	3.8	0.741	176	0.74	250	2200	12

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Table XI. Strength Properties After Beating in the Different Laboratory Beaters

Sheetmaking and testing of the sheets according to the British Paper & Board Makers' standard method; quality, unbleached sulphite, easy bleaching

Beaters	Beating time	Wetness, S.-R.	Freeness, Canadian std.	Break L, m.	Burst F, Mu	Burst F, Da	Tear F, M-M	Fold, Sch.	Str., %	Vol. w., kg./dm.³	Opacity Scatt. coeff.	Opacity C-R	Porosity B-U, sec.	Porosity G-H, sec.	Porosity Sch., cm.³/min.
Aylesford beater, Reed (RAy)	0 min.	18.0	636	2980	15.8	17.2	209	8	2.1	0.597	488	0.92	1.5	7	1450
	8 min.	22.0	562	4095	25.0	25.8	233	...	2.7	0.636	446	0.89	6	28	300
	16 min.	27.0	467	4945	31.7	31.9	211	150	3.1	0.668	416	0.88	12	57	148
	24 min.	35.0	365	5780	37.0	36.4	186	...	3.4	0.698	372	0.86	32	142	65
	32 min.	44.0	269	6280	40.5	39.9	170	625	3.6	0.737	337	0.85	92	525	24
	40 min.	52.5	195	6620	43.3	41.1	156	...	3.8	0.759	305	0.83	149	1172	15
	48 min.	62.0	136	6930	44.7	42.9	146	...	4.0	0.788	270	0.80	316	2080	9
	56 min.	68.0	99	6945	45.6	43.6	140	935	4.0	0.814	225	0.78	689	3000	6
	38 min.	50.0	217	6520	42.5	40.7	160	700	3.8	0.753	314	0.84	130	980	19
Banning & Seybold beater, Skönsmon (SB-S)	0 min.	16.0	659	2985	17.1	18.2	213	10	2.5	0.586	470	0.90	1.6	6.5	1264
	5 min.	19.0	673	4465	30.7	30.2	256	90	3.3	0.640	409	0.87	4	18	436
	10 min.	24.5	456	5440	38.5	37.1	233	340	3.7	0.673	379	0.86	9	36	226
	20 min.	40.5	273	6440	48.2	44.8	217	1500	4.0	0.703	335	0.84	37	183	49
	30 min.	57.0	155	6985	52.0	47.5	199	1835	4.3	0.725	304	0.82	92	547	21
	26 min.	50.0	205	6735	50.3	46.4	207	1635	4.2	0.716	317	0.83	68	390	33
PFI mill, Oslo (OP)	0 sec.	14.0	692	1740	9.1	10.3	142	1	1.4	0.551	541	0.92	1.1	3.8	1955
	60 sec.	26.5	427	6955	49.6	46.3	193	...	3.7	0.730	315	0.82	23	139	67
	90 sec.	38.5	297	8090	58.9	53.9	178	1485	4.2	0.760	268	0.79	79	550	23
	135 sec.	56.0	147	8755	65.0	59.2	161	...	4.5	0.799	202	0.74	324	3000	9
	180 sec.	68.5	81	8910	68.0	61.0	153	...	4.5	0.834	167	0.69	685	3000	8
	270 sec.	81.5	40	9185	69.7	62.7	140	2900	4.8	0.877	112	0.54	1890	3000	7
	120 sec.	50.0	198	8595	62.9	57.4	167	1800	4.4	0.786	225	0.76	240	2200	14
Lampén mill, Oslo (OL)	30 min.	29.0	413	7700	51.9	47.9	168	800	3.3	0.791	261	0.77	17	133	75
	60 min.	37.0	353	8200	55.6	51.5	159	1610	3.7	0.819	237	0.75	67	379	29
	180 min.	60.5	123	8890	62.9	58.4	147	...	4.1	0.865	149	0.66	396	3000	6
	360 min.	71.0	69	9320	64.3	59.3	137	2690	4.3	0.883	114	0.59	660	3000	4
	126 min.	50.0	226	8600	59.6	55.3	152	1400	3.9	0.844	188	0.70	240	1750	16
Valley beater, Helsingfors (HV)	0 min.	14.0	707	2120	10.2	11.1	149	2	1.6	0.567	497	0.92	1.1	3.2	5260
	20 min.	21.0	542	6330	40.4	38.3	213	...	2.9	0.690	340	0.85	6	30	245
	40 min.	37.0	318	8010	54.7	49.7	179	1630	3.3	0.743	285	0.82	56	295	35
	60 min.	56.0	154	8535	60.5	54.1	162	...	3.7	0.771	220	0.79	242	2110	10
	90 min.	74.0	36	8450	58.7	53.5	146	...	3.8	0.822	179	0.71	921	3000	6
	120 min.	83.5	6	7800	53.5	48.9	133	2765	3.8	0.835	164	0.66	713	3000	5
	54 min.	50.0	206	8335	58.7	52.7	167	1800	3.6	0.762	241	0.80	180	1540	18
Lampén mill, Helsingfors (HL)	0 min.	14.0	728	1830	9.1	8.7	138	1	1.3	0.540	499	0.92	1.0	2.3	3790
	20 min.	20.5	543	7505	48.6	45.4	187	...	3.3	0.755	243	0.78	4	20	435
	40 min.	34.0	355	8570	56.7	52.6	164	1570	3.8	0.813	207	0.74	50	289	30
	60 min.	49.5	185	9130	62.9	58.4	147	...	4.0	0.857	155	0.66	249	967	14
	90 min.	63.5	89	9115	65.0	60.2	140	...	3.8	0.864	136	0.60	478	3000	8
	180 min.	77.5	26	8800	64.3	59.5	132	2855	4.1	0.904	104	0.53	544	3000	7
	61 min.	50.0	182	9125	62.9	58.5	147	1765	4.0	0.857	155	0.66	250	1050	15
Noble & Wood beater, Helsingfors (HN-W)	0 min.	15.0	690	1970	9.8	11.3	168	2	1.7	0.557	508	0.92	1.0	3.3	2740
	20 min.	26.5	470	6315	42.3	39.5	215	...	3.1	0.684	347	0.85	11	60	146
	30 min.	36.0	347	7185	49.0	45.2	201	1360	3.4	0.712	306	0.84	48	191	50
	40 min.	46.5	248	7575	53.7	50.3	189	...	3.5	0.730	281	0.83	122	748	17
	60 min.	63.0	115	7975	56.4	53.0	182	...	3.7	0.757	247	0.80	320	2750	9
	90 min.	75.5	35	7895	55.9	52.2	162	2640	3.8	0.787	208	0.76	590	3000	6
	44 min.	50.0	276	7660	54.3	50.9	187	1710	3.5	0.736	274	0.82	160	1150	15

Table XII. Strength Properties After Beating in the Different Laboratory Beaters

Sheetmaking and testing of the sheets according to the British Paper & Board Makers' standard method quality, unbleached sulphate, kraft

Beaters	Beating time	Wetness, S.-R.	Freeness, Canadian, std.	Break L, m.	Burst F, Mu	Burst F, Da	Tear F, M-M	Fold, Sch.	Str., %	Vol. w., kg./dm.³	Opacity Scatt. coeff.	Opacity C-R	Porosity B-U, sec.	Porosity G-H, sec.	Porosity Sch., cm.³/min.
Aylesford beater, Reed (RAy)	0 min.	15.0	706	3,075	19.4	19.8	256	10	2.0	0.488	400	1.00	1.0	1.0	7,120
	16 min.	20.0	598	6,385	48.4	46.0	292	1235	3.9	0.586	320	0.98	2.2	8.9	976
	24 min.	24.0	524	7,275	57.2	53.8	281	1765	4.3	0.613	307	0.98	3.4	25.0	349
	32 min.	30.0	430	8,275	65.1	59.4	255	2275	4.6	0.655	290	0.97	14	73.3	121
	40 min.	38.0	327	8,745	67.4	63.2	243	2405	4.6	0.670	278	0.96	37	214	43
	48 min.	47.0	243	9,260	70.5	65.6	228	2350	4.9	0.714	255	95	96	434	23
	56 min.	56.0	169	9,500	71.6	67.3	206	2875	5.0	0.735	224	0.92	290	1,584	10
	64 min.	67.0	109	9,655	74.0	67.9	194	3430	5.2	0.765	195	0.90	674	4,620	7
	51 min.	50.0	218	9,350	70.9	66.2	221	2525	4.9	0.721	245	0.94	161	817	19
Banning & Seybold beater, Skönsmon (SB-S)	0 min.	13.5	695	3,350	22.5	21.8	250	20	2.5	0.478	389	1.00	0.8	0.9	10,920
	10 min.	15.5	647	5,770	43.1	40.4	301	580	3.4	0.542	328	0.98	0.8	1.8	5,300
	20 min.	19.5	553	6,930	53.3	48.9	282	1345	3.9	0.598	309	0.97	1.6	5.2	1,700
	40 min.	40.5	323	8,265	67.4	61.3	270	2310	4.5	0.632	262	0.94	7.4	32.0	250
	60 min.	71.0	155	8,925	71.5	65.6	247	2760	4.7	0.665	245	0.93	45	323.8	29
	46 min.	50.0	275	8,471	68.7	62.6	263	2450	4.6	0.642	257	0.94	19	122.9	181
PFI mill, Oslo (OP)	0 sec.	13.0	740	2,955	17.6	17.8	228	7	1.9	0.463	423	0.99	1.0	0.8	8,020
	120 sec.	18.5	612	9,290	77.3	68.9	275	2835	4.7	0.643	248	0.93	3.5	15.6	2,760
	255 sec.	38.0	292	11,075	94.6	82.2	237	2995	5.1	0.694	206	0.92	44	270	35
	360 sec.	60.5	162	11,665	98.8	86.6	229	3750	5.3	0.720	190	0.89	152	952	14
	450 sec.	74.5	97	11,960	101.8	88.7	227	4020	5.3	0.738	168	0.86	307	2,463	8
	600 sec.	82.5	47	12,240	103.9	90.9	212	4665	5.5	0.759	148	0.85	576	8,141	7
	311 sec.	50.0	223	11,385	96.8	79.9	233	3225	5.2	0.720	197	0.90	102	634	24
Lampén mill, Oslo (OL)	30 min.	17.5	623	10,340	80.6	73.7	247	2565	4.1	0.675	225	0.91	2.6	10.8	820
	90 min.	36.0	347	11,750	93.1	81.9	223	2975	4.4	0.723	185	0.90	17	103	91
	180 min.	56.5	177	12,005	94.5	81.9	208	3825	4.5	0.739	162	0.89	96	541	23
	240 min.	65.5	140	11,910	93.4	82.2	207	3525	4.8	0.754	157	0.88	142	1,396	11
	153 min.	50.0	231	11,910	93.9	81.9	212	3535	4.5	0.734	169	0.89	71	402	45
Valley beater, Helsingfors (HV)	0 min.	13.0	723	2,755	15.9	16.6	243	8	2.0	0.435	385	1.00	1.0	0.9	8,860
	30 min.	16.5	641	8,595	67.4	70.8	305	2920	3.7	0.601	256	0.94	1.4	4.6	1,710
	60 min.	24.0	485	10,385	85.6	74.7	275	3320	4.2	0.642	224	0.91	8.9	40.6	213
	90 min.	41.5	280	11,640	95.8	84.5	262	3655	4.4	0.678	220	0.93	48	433	28
	135 min.	77.0	76	12,000	10.1	87.1	238	4200	4.5	0.709	170	0.89	395	2,824	8
	180 min.	87.5	13	11,725	93.7	82.1	219	4470	4.8	0.762	139	0.82	703	6,729	7
	101 min.	50.0	231	11,735	96.8	85.1	257	3775	4.4	0.685	208	0.93	131	1,005	23
Lampén mill, Helsingfors (HL)	0 min.	13.5	734	2,895	15.7	16.7	227	8	1.8	0.468	384	1.00	1.0	0.6	9,360
	30 min.	15.5	670	9,075	74.0	64.8	283	3440	3.7	0.640	230	0.93	1.4	2.7	3,650
	60 min.	17.0	601	10,255	80.4	72.0	262	3180	4.0	0.679	204	0.92	1.9	6.9	1,302
	150 min.	58.0	155	11,820	92.5	81.7	204	3600	4.4	0.749	156	0.87	75	562	21
	240 min.	74.0	71	11,830	97.0	85.1	193	4500	4.7	0.780	124	0.83	274	3,740	8
	132 min.	50.0	242	11,515	90.1	79.4	215	3465	4.3	0.735	165	0.88	61	454	271
Noble & Wood beater, Helsingfors (HN-W)	0 min.	13.0	706	3,165	18.8	18.6	244	15	2.3	0.478	403	1.00	1.0	0.8	8,320
	15 min.	16.0	626	7,420	55.5	51.8	305	1615	3.9	0.579	285	0.96	1.9	6.0	1,452
	30 min.	26.0	438	9,065	69.9	63.4	267	2785	4.4	0.631	246	0.94	7.3	35.7	245
	45 min.	47.0	238	10,185	78.2	69.6	249	2765	4.7	0.670	225	0.93	50	271	37
	60 min.	67.0	114	10,385	81.5	74.7	232	3360	4.7	0.689	184	0.91	225	1,468	11
	90 min.	83.5	31	10,075	78.6	71.1	212	4065	4.9	0.733	142	0.89	925	12,140	7
	47 min.	50.0	219	10,215	78.7	70.4	246	2825	4.7	0.673	219	0.93	76	451	33

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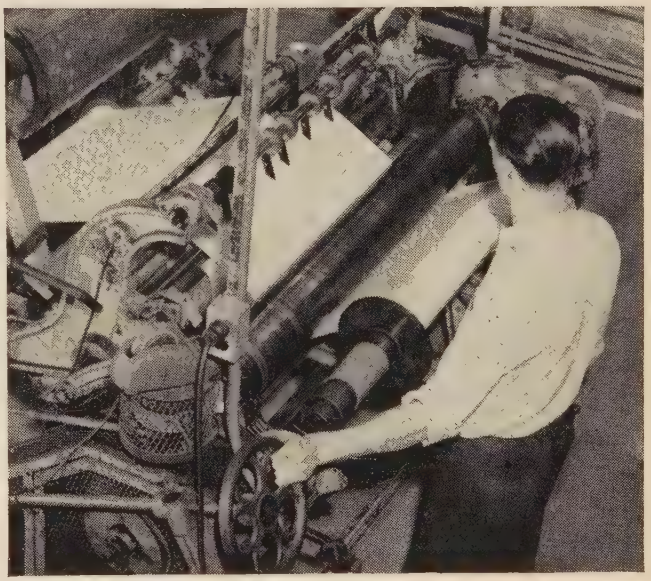

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Table XIII. Strength Properties After Beating in the Different Laboratory Beaters

Sheetmaking and testing of the sheets according to the British Paper & Board Makers' standard method; quality, unbleached sulphate, L & S

Beaters	Beating time	Wetness, S.-R.	Freeness, Canadian std.	Break L, m.	Burst F, Mu	Burst F, Da	Tear F, M-M	Fold, Sch.	Str., %	Vol. w., kg./dm.³	Opacity Scatt. coeff.	Opacity C-R	Porosity B-U, sec.	Porosity G-H, sec.	Porosity Sch., cm.³/min.
Aylesford beater, Reed (RAy)	0 min.	16.0	685	2,505	14.8	16.2	251	5	2.7	0.513	415	0.99	1.0	1.2	6,920
	16 min.	23.0	543	5,325	42.2	40.9	349	895	4.6	0.595	356	0.98	3.1	14.1	608
	24 min.	28.0	443	6,225	50.3	46.9	317	1415	4.7	0.623	337	0.97	5.9	35.0	244
	32 min.	37.0	333	7,015	57.0	53.7	293	2020	5.1	0.655	322	0.96	19	105.0	72
	40 min.	47.0	242	7,590	60.9	55.7	268	2110	5.2	0.680	301	0.96	58	413.9	24
	48 min.	56.0	167	7,755	62.3	57.2	247	2225	5.5	0.717	276	0.94	121	925.0	14
	56 min.	67.0	106	8,175	63.6	58.7	229	2360	5.7	0.745	238	0.93	308	2,507	7
	43 min.	50.0	217	7,650	61.4	56.2	261	2150	5.3	0.692	293	0.95	79	584.3	21
Banning & Seybold beater, Skönsmon (SB-S)	0 min.	13.0	682	2,790	19.0	19.6	279	20	3.4	0.503	388	0.99	1.3	1.0	12,820
	10 min.	15.5	568	5,715	45.8	42.2	360	1230	4.6	0.581	323	0.97	1.6	4.0	2,500
	20 min.	22.0	467	7,110	57.2	51.6	325	2405	4.8	0.616	300	0.96	3.3	18.8	475
	40 min.	54.5	192	8,260	66.4	61.1	277	2525	5.0	0.654	256	0.94	32	177.2	49
	60 min.	75.0	60	8,015	64.6	59.0	240	2700	4.9	0.711	228	0.93	257	2,285	7
	37 min.	50.0	230	8,115	65.2	59.8	283	2515	5.0	0.649	262	0.94	28	155.3	108
PFI mill, Oslo (OP)	0 sec.	14.0	720	2,230	13.0	14.1	224	5	2.3	0.472	402	0.99	0.9	1.0	9,460
	105 sec.	18.0	598	7,717	63.7	57.3	326	2735	4.4	0.621	283	0.95	1.9	7.4	1,128
	270 sec.	39.0	342	9,737	81.0	73.1	279	3455	4.7	0.674	236	0.94	12	90	113
	360 sec.	56.0	190	10,365	86.4	76.1	261	3172	4.8	0.700	222	0.93	38	250.4	34
	450 sec.	67.0	128	10,265	85.6	76.6	250	3400	5.1	0.716	215	0.92	92	788.6	16
	540 sec.	78.0	78	10,725	89.1	79.3	243	3287	5.1	0.731	201	0.90	214	1,498	10
	332 sec.	50.0	244	10,140	84.4	75.0	267	3350	4.8	0.691	227	0.93	29	193.8	62
Lampén mill, Oslo (OL)	45 min.	28.0	417	979	75.3	67.3	227	1877	4.2	0.703	230	0.94	6.5	38.3	230
	90 min.	43.5	273	10,142	77.6	69.6	217	2127	4.4	0.727	209	0.93	19	114.9	73
	120 min.	50.0	223	10,427	79.2	70.5	210	2290	4.3	0.736	224	0.93	29	2,024	46
	240 min.	71.0	113	10,675	78.7	69.7	196	2663	4.5	0.770	187	0.91	134	1,262	12
	120 min.	50.0	223	10,425	79.2	70.5	210	2290	4.3	0.736	224	0.93	2.9	202.4	46
Valley beater, Helsingfors (HV)	0 min.	13.5	729	1,630	8.1	9.1	171	2	1.7	0.455	381	0.99	0.9	2.8	9,040
	30 min.	19.0	602	8,310	66.4	58.6	332	2816	4.2	0.616	294	0.96	3.2	12.0	7,380
	45 min.	25.5	496	9,265	75.1	66.5	326	3443	4.3	0.637	262	0.95	5.9	28.4	310
	60 min.	35.0	367	10,030	79.1	71.8	300	3947	4.1	0.655	255	0.94	14	59.1	119
	90 min.	64.0	149	10,650	82.4	73.2	269	4515	4.4	0.693	204	0.92	198	1,364	12
	135 min.	82.5	28	10,930	79.2	69.7	226	4542	4.7	0.759	164	0.87	692	12,044	6
	75 min.	50.0	254	10,350	80.8	72.5	284	4215	4.3	0.675	229	0.93	109	734.0	64
Lampén mill, Helsingfors (HL)	0 min.	13.0	738	1,665	7.9	9.2	187	3	1.5	0.451	436	0.99	0.9	0.5	9,880
	30 min.	16.0	662	8,645	65.0	58.9	282	2483	3.8	0.645	238	0.96	1.6	4.2	1,900
	60 min.	24.0	512	9,480	69.8	63.0	252	2468	4.1	0.684	210	0.92	3.1	12.2	758
	120 min.	59.5	148	10,510	75.6	69.2	209	3060	4.3	0.746	182	0.91	76	517.2	22
	180 min.	70.0	100	10,835	78.3	70.0	195	2928	4.5	0.786	160	0.88	246	3,044	9
	104 min.	50.0	245	10,235	74.2	67.5	221	2965	4.2	0.729	189	0.91	57	382.1	219
Noble & Wood beater, Helsingfors (HN-W)	0 min.	14.0	709	2,073	11.7	13.2	208	5	2.3	0.483	361	0.99	1.2	0.9	9,820
	15 min.	18.5	596	6,745	52.2	47.9	336	1823	4.0	0.597	321	0.97	2.2	6.2	1,472
	30 min.	31.5	381	8,370	65.6	60.4	288	2328	4.4	0.645	260	0.95	10.3	54.2	165
	45 min.	53.5	195	9,075	72.3	65.9	257	2420	4.4	0.681	238	0.94	59	339	25
	60 min.	70.0	89	9,690	73.6	67.7	245	2521	5.0	0.705	200	0.92	243	1,751	11
	90 min.	84.0	16	10,020	72.1	65.9	216	2998	5.1	0.743	170	0.92	445	8,922	7
	42 min.	50.0	228	8,950	71.1	65.0	262	2365	4.4	0.675	241	0.94	51	293.7	47

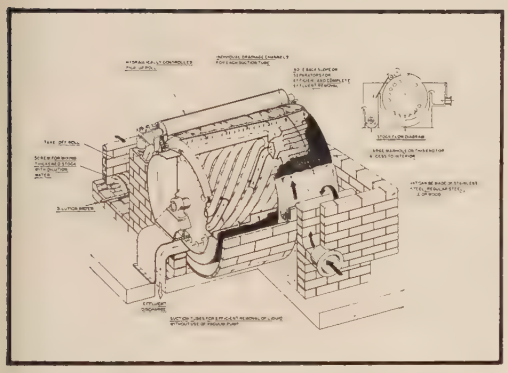
Table XIV. Strength Properties After Beating in the Different Laboratory Beaters

Sheetmaking and testing of the sheets according to the British Paper & Board Makers' standard method; quality, unbleached sulphate, easy bleaching

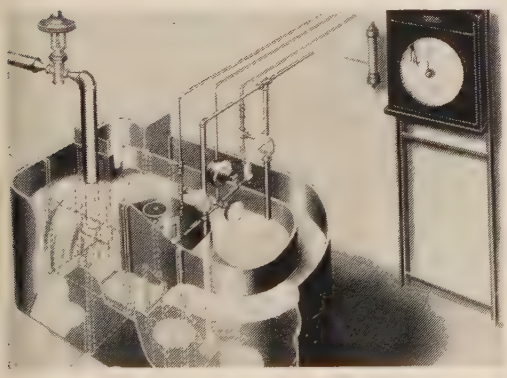
Beaters	Beating time	Wetness, S.-R.	Freeness, Canadian std.	Break L, m.	Burst F, Mu	Burst F, Da	Tear F, M-M	Fold, Sch.	Str., %	Vol. w., kg./dm.³	Opacity Scatt. coeff.	Opacity C-R	Porosity B-U, sec.	Porosity G-H, sec.	Porosity Sch., cm.³/min.
Aylesford beater, Reed (RAy)	0 min.	17.0	653	2575	15.9	18.0	265	10	3.1	0.524	412	0.99	0.8	1.6	6,680
	8 min.	22.0	561	3540	27.4	28.7	281	65	4.4	0.559	396	0.99	1.2	4.0	2,540
	16 min.	28.0	453	4675	34.0	34.6	259	165	4.6	0.601	379	0.98	2.3	12.1	780
	24 min.	37.0	337	5300	38.8	39.1	229	305	4.8	0.632	371	0.98	9.4	52.1	190
	32 min.	48.0	233	5740	41.6	41.0	207	378	4.8	0.664	362	0.98	22	112.1	72
	40 min.	57.0	160	6055	44.0	43.2	191	528	5.0	0.702	342	0.97	47	324.6	32
	48 min.	68.0	100	6155	43.0	41.9	173	455	4.8	0.731	316	0.96	97	568.5	18
	34 min.	50.0	217	5810	42.1	41.5	203	411	4.8	0.672	358	0.98	28	159.2	63
Banning & Seybold beater, Skönsmon (SB-S)	0 min.	16.5	611	3205	24.0	24.4	315	50	4.6	0.557	405	0.98	1.0	1.9	4,660
	10 min.	26.5	473	5530	43.4	41.9	269	570	4.8	0.596	359	0.97	4.0	18.4	424
	20 min.	56.5	206	6445	49.9	48.0	226	1015	4.9	0.650	332	0.95	24	130.1	79
	40 min.	86.5	19	6710	50.3	47.0	157	555	4.7	0.752	253	0.92	538	2,808.5	5
	18 min.	50.0	264	6235	48.3	46.7	236	885	4.9	0.638	338	0.95	20	105.9	154
PFI mill, Oslo (OP)	0 sec.	14.0	692	2320	14.2	16.1	231	5	3.1	0.497	453	0.99	0.9	1.4	5,690
	60 sec.	19.0	568	6370	46.7	45.2	244	558	4.2	0.612	344	0.96	2.0	8.1	926
	135 sec.	37.5	335	7770	57.4	54.8	207	870	4.5	0.668	299	0.94	10	55.4	150
	210 sec.	64.5	148	8390	63.5	58.9	187	1142	4.7	0.713	272	0.92	45	265.2	35
	255 sec.	73.0	100	8565	64.8	60.1	182	1173	4.7	0.738	252	0.91	98	791	16
	300 sec.	81.5	60	8745	65.5	61.3	175	1658	4.8	0.766	231	0.90	224	2,399	8
	170 sec.	50.0	248	8050	60.3	56.7	198	1050	4.6	0.689	286	0.93	26	152.5	97
Lampén mill, Oslo (OL)	20 min.	27.0	443	6685	42.2	40.9	183	255	3.6	0.683	321	0.96	3.6	20.6	157
	45 min.	40.0	293	7190	45.3	43.9	171	370	3.8	0.717	296	0.95	8.7	53.9	163
	120 min.	57.5	172	7570	48.9	47.4	157	485	3.9	0.750	269	0.93	31	185.2	49
	240 min.	67.0	117	7560	47.2	46.4	151	430	4.0	0.762	242	0.93	67	429	25
	88 min.	50.0	224	7415	47.5	45.9	163	415	3.9	0.736	281	0.94	21.4	128.9	98
Valley beater, Helsingfors (HV)	0 min.	14.5	702	1480	7.8	9.4	171	2	2.0	0.466	450	0.99	1.0	0.8	17,320
	30 min.	31.5	382	7800	54.6	51.5	222	1240	4.2	0.646	321	0.96	8.3	45.5	189
	45 min.	54.5	193	8365	58.4	55.4	204	1300	4.1	0.687	298	0.96	50	232.2	39
	60 min.	71.5	78	8635	60.6	57.1	177	1340	4.3	0.720	254	0.93	148	1,256	14
	90 min.	85.0	9	8220	58.2	55.8	144	1325	5.4	0.806	178	0.88	411	12,164	6
	42 min.	50.0	230	8250	57.6	54.6	207	1285	4.1	0.679	302	0.96	42	195.7	68
Lampén mill, Helsingfors (HL)	0 min.	14.0	717	1505	7.8	9.0	165	2	1.9	0.471	437	0.99	0.9	0.7	16,560
	30 min.	25.0	435	6600	41.1	39.6	83	1285	3.6	0.700	296	0.95	3.8	16.1	544
	60 min.	60.0	115	7015	43.6	41.4	143	330	3.9	0.787	266	0.94	25	433	27
	90 min.	70.0	70	7520	47.8	45.4	133	625	4.0	0.824	205	0.90	148	1,028	15
	180 min.	74.5	51	7500	47.8	46.0	129	550	4.1	0.841	187	0.89	407	5,268	7
	51 min.	50.0	206	6900	42.9	40.9	155	300	3.8	0.762	275	0.94	19	314	175
Noble & Wood beater, Helsingfors (HN-W)	0 min.	15.0	676	2110	12.3	14.4	230	5	3.0	0.504	439	0.99	1.0	1.1	8,560
	15 min.	28.0	418	6895	49.9	47.8	236	815	4.0	0.636	334	0.97	5.3	26.2	330
	30 min.	57.0	165	7780	56.3	53.9	199	1080	4.3	0.687	294	0.95	47	324.6	31
	45 min.	76.5	52	8055	57.5	55.6	178	1075	4.4	0.726	244	0.93	187	1,325	10
	60 min.	83.5	16	7720	55.6	52.4	167	1005	4.8	0.762	220	0.92	419	4,864	6
	26 min.	50.0	226	7350	54.8	52.4	208	1000	4.2	0.675	304	0.95	37	252.6	103

BLAZING TRAILS IN PULP MILLS

Pandia Continuous Digester Installation



Black-Clawson Valveless Washer



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24, and the tensile and burst values are lower throughout owing to this, except Korsnäs. The tearing strength on the other hand, is not changed much. It should be observed that the moisture content of the pulp did not contribute to the changes, because the samples were air-dry and conditioned for 3 to 4 months before the first beating.

It is difficult to assess the value of these results. Admittedly the pulp was stored 3 to 4 months before the first beating, but the question arises whether the beaters are assessing further aging of the pulp, or whether one can assume the pulp is constant and is used as a check pulp for the beaters.

In view of the fact that seven beaters (the two Korsnäs beaters being an exception) show generally on the second test a lower burst factor and breaking length, it is more than probable that further aging of the pulp has taken place, but the difference due to aging of the pulp and the difference due to the beating apparatus and sheetmaking cannot be proportioned.

CONCLUSIONS

1. The strength values of pulp, which were obtained when using the individual methods of the participating research laboratories, are of highly variable order of magnitude, partly because of different sheetmaking apparatus. The lowest tensile, burst, and fold figures for all pulp qualities are obtained at Reed's and in Skönsmon. The highest values for strong bleached sulphites and unbleached sulphites are obtained in the Lampén mills in Oslo and Helsingfors. For soft pulps, sulphites as well as sulphates, the highest values are obtained in the PFI mill in Oslo and in the Valley beater in Korsnäs. For kraft sulphate the highest values are obtained in the Lampén mill in Oslo. Due to different bases of calculation the tearing figures are highest at Reed's and in Helsingfors and the lowest values are obtained after beating in the Lampén mill in Oslo.

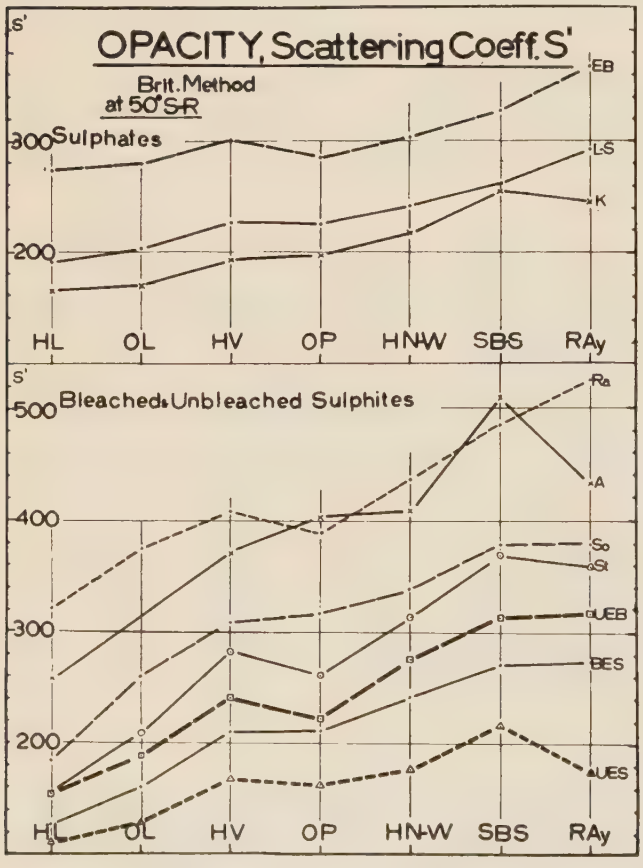

Fig. 20. The opacity, scattering coefficient at 50°S.-R. of the different pulp qualities plotted with the various beaters as a basis

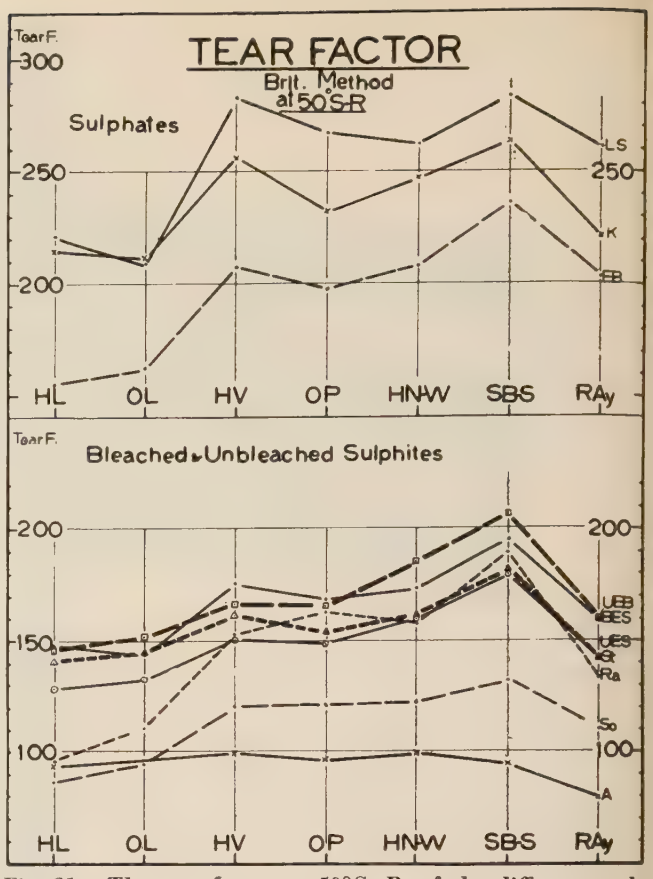

Fig. 21. The tear factor at 50°S.-R. of the different pulp qualities plotted with the various beaters as a basis

2. Compared on a wetness basis (S.-R.) the PFI mill and the Valley beater in Helsingfors give very consistent results for the tensile, burst, tear, folding, opacity, and apparent specific gravity values due to the similar manner of beating in these beating apparatus.

3. The tensile, burst, folding, and opacity values obtained in the Aylesford beater and in the Banning & Seybold beater are in fairly good agreement but this is not the case for tearing strength, apparent specific gravity, and air permeability. The Aylesford beater gives lower tearing strength, higher apparent specific gravity, and denser sheets than are obtained in the B & S beater.

4. The PFI mill and the Aylesford beater grade the pulp qualities investigated, with the exception of the softest bleached pulps, rayon and aspen, in the same order as the Valley beater, the Banning & Seybold beater, the Noble & Wood beater and the Lampén mill in respect to the breaking length, bursting strength, tearing strength, and opacity determined both for sheets made according to the British method and for sheets made according to the methods of the various laboratories.

5. The grading of the pulps in respect to the beating time to a given wetness is not equally consistent in all beaters although the unbleached sulphites and the sul-

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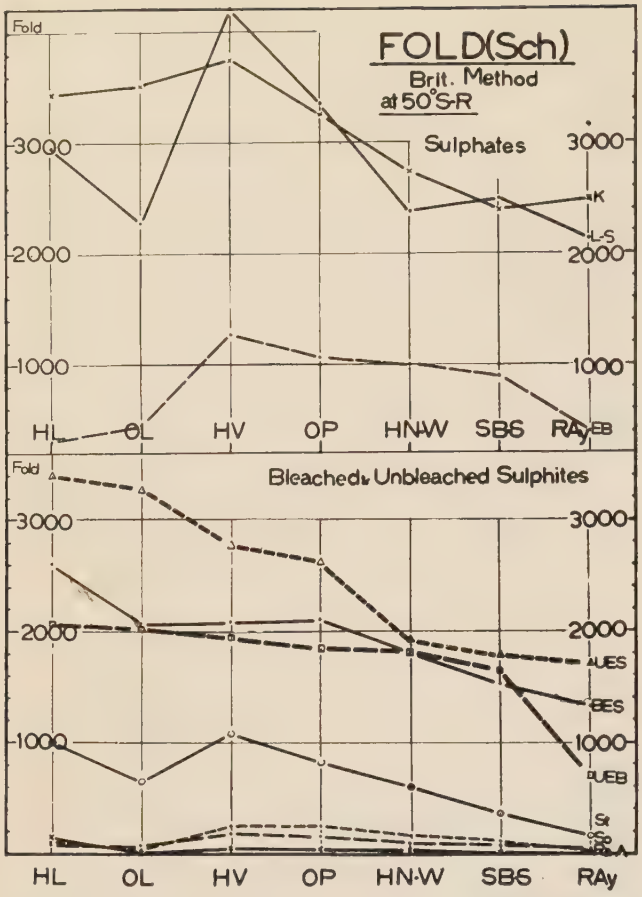

Fig. 22. The fold (Schopper) at 50°S.-R. of the different pulp qualities plotted with the various beaters as a basis

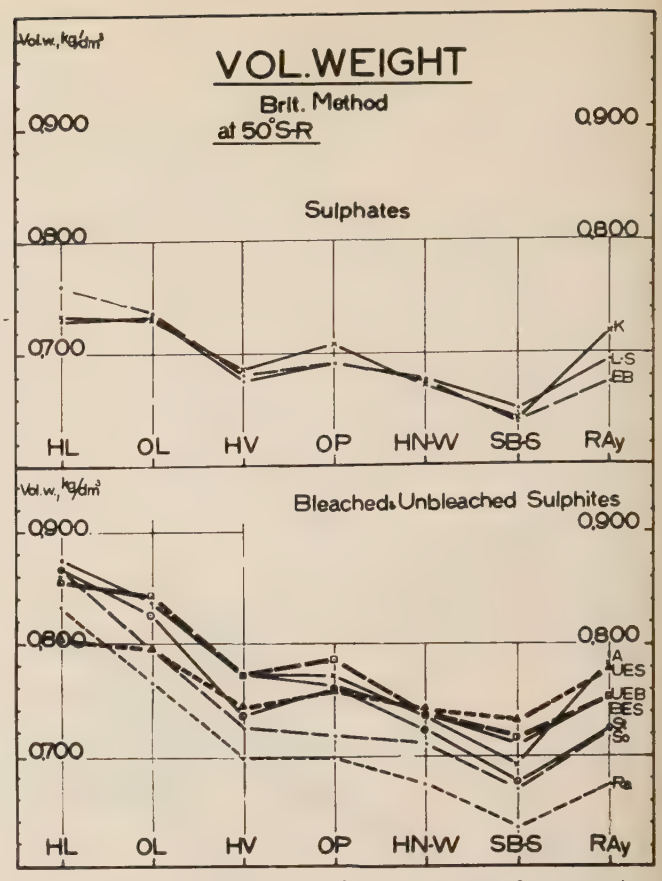

Fig. 23. The volume weight (apparent specific gravity) at 50°S.-R. of the different pulp qualities plotted with the various beaters as a basis

phates are graded mainly in the same way by several beaters. The grading capacity of the PFI beater in this respect cannot be judged for the bleached qualities, since the softest pulps, soft, rayon, and aspen, were beaten at a lower beating pressure (1.9 kg. per cm.) than the other (3.4 kg. per cm.).

6. The Lampén mill reduces the opacities of the pulps more than the barred beaters compared at a given wetness. The Aylesford beater and the B & S beater in Skönsmon reduce the opacity less than the other apparatus.

7. Apart from the PFI mill, in which the beating conditions were altered, in any one of the other beaters all the bleached sulphite qualities were beaten under the same beating conditions. These might not be the most suitable conditions in all beaters for soft pulps and undoubtly this influenced the judgment of the relative strength values of these pulps. The Lampén mill, in which the beating pressure cannot be altered and in accordance with previous investigations by Ekstam (*12*) turned out to be unsuitable for beating of very soft pulps.

8. A direct comparison between two specimens of the same type of beating apparatus could not be obtained. The Lampén mills in Oslo and Helsingfors gave results in fairly good agreement but they were not quite fair for this type of beater. The Banning & Seybold beaters in Korsnäs and Skönsmon could not be directly compared as to the strength properties of the beaten pulp since the sheetmaking in Korsnäs was carried out according to the Swedish method only. With respect to the beating time to reach a given wetness, there was no good agreement between these beaters.

9. The investigation has not elucidated the point whether the various beaters differentiate the pulp qualities in regard to the strength properties in the same order as mill beaters since such beaters were not included in the beating investigation. But since Cot-

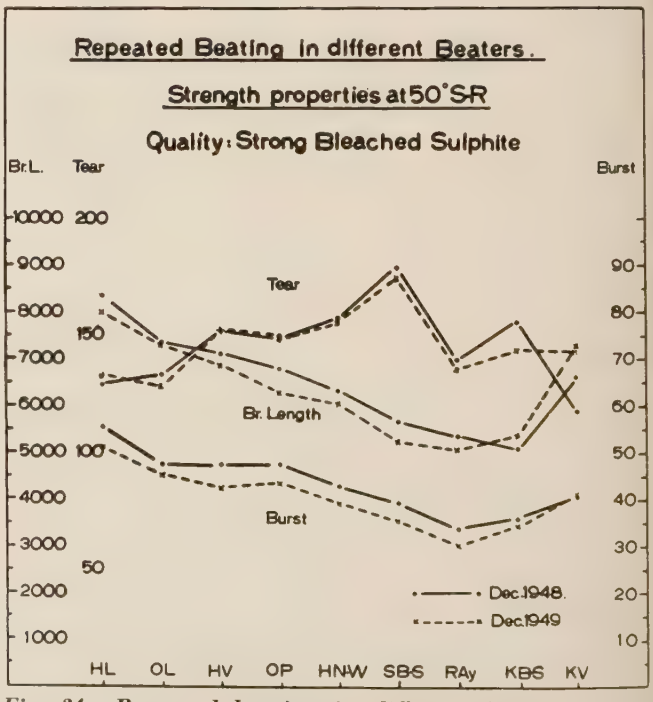

Fig. 24. Repeated beating in different beaters of the sample "strong bleached sulphite"

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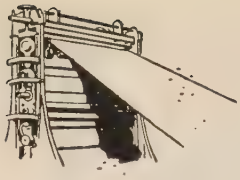

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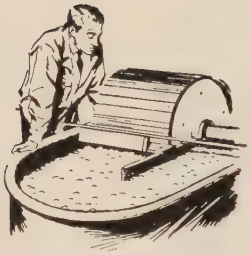

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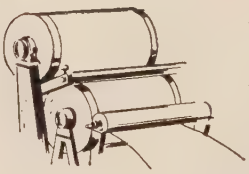

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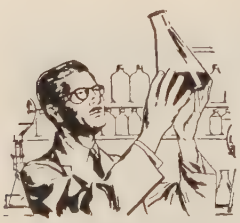

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trall in a previous investigation has shown, that beating in the Aylesford laboratory beater corresponds to beating in the mill at Reeds, and Ekstam has found that the Valley beater grades bleached and semibleached sulphates in the same way as an ordinary mill beater, on the basis of the present investigations it is possible, to say, provided there is any unitary form of mill beating, that laboratory beatings provide means to infer how the strength properties of a pulp in comparison with other qualities will turn out when the beatings are performed on the mill scale.

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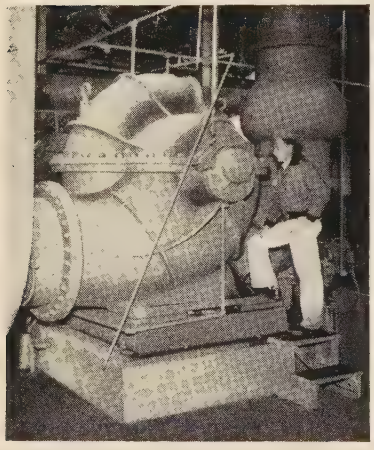
Reprinted from *Paper and Timber* (Finland) No. 11. 12 (1953) at the request of the TAPPI Pulp Testing Committee.

Preliminary report presented to the Autumn Meeting of the Finnish Paper Engineers' Association on Nov. 22, 1951, in Helsingfors, and to the Meeting of the Association of Norwegian Paper and Pulp Engineers, Oslo, Norway, Dec. 6, 1951.



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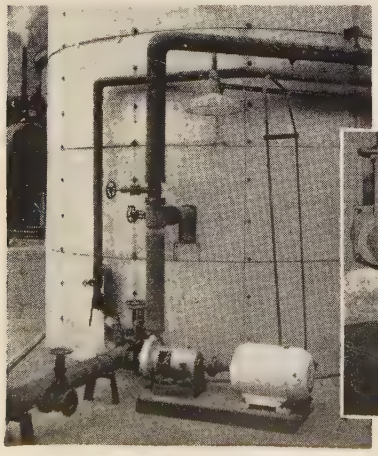

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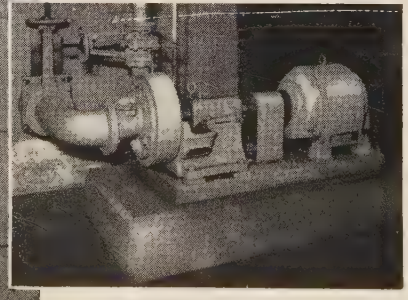

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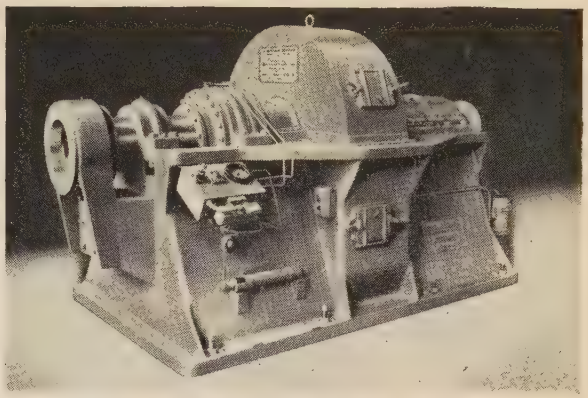

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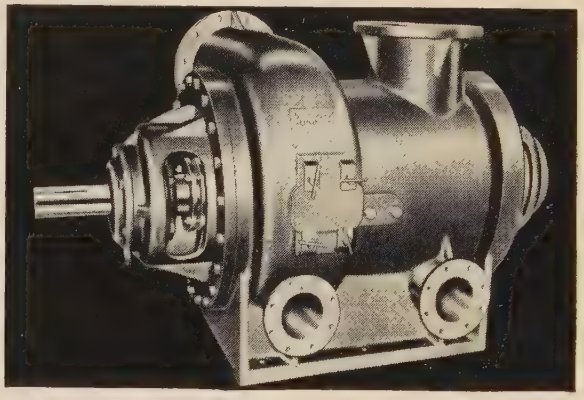

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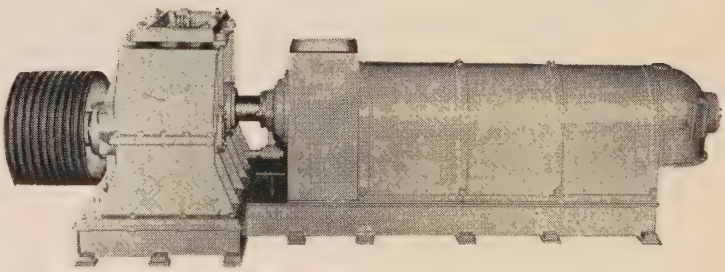

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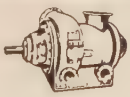

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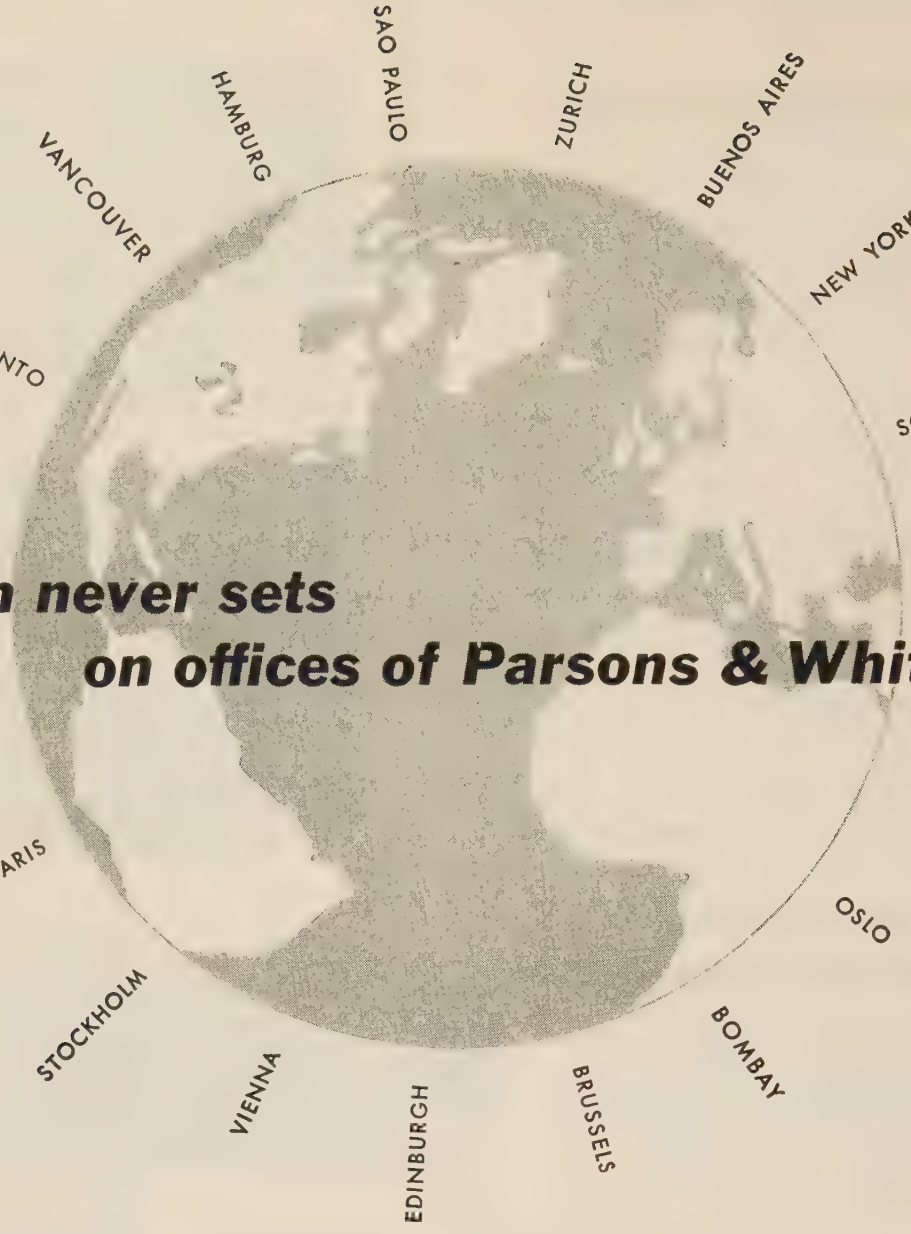

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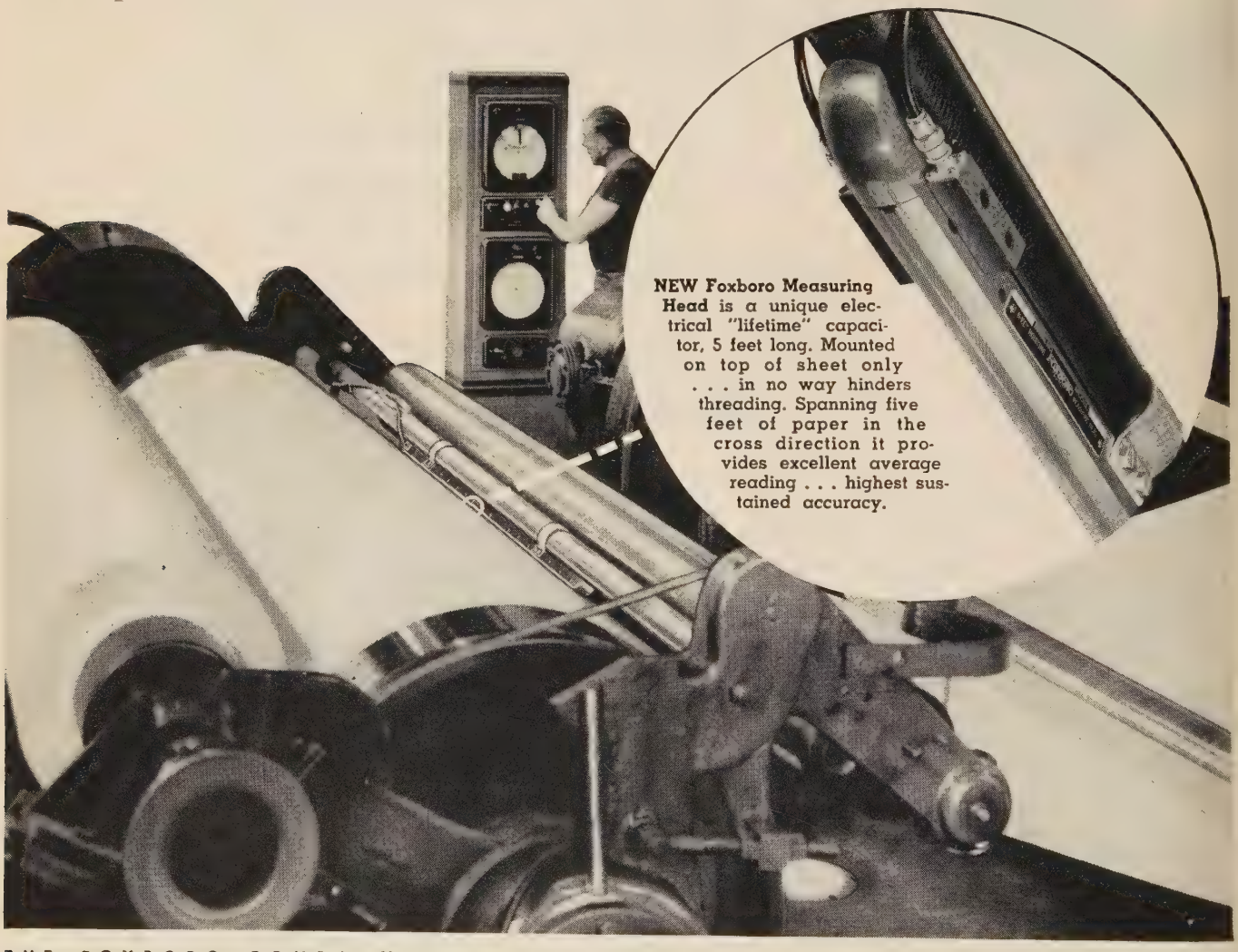

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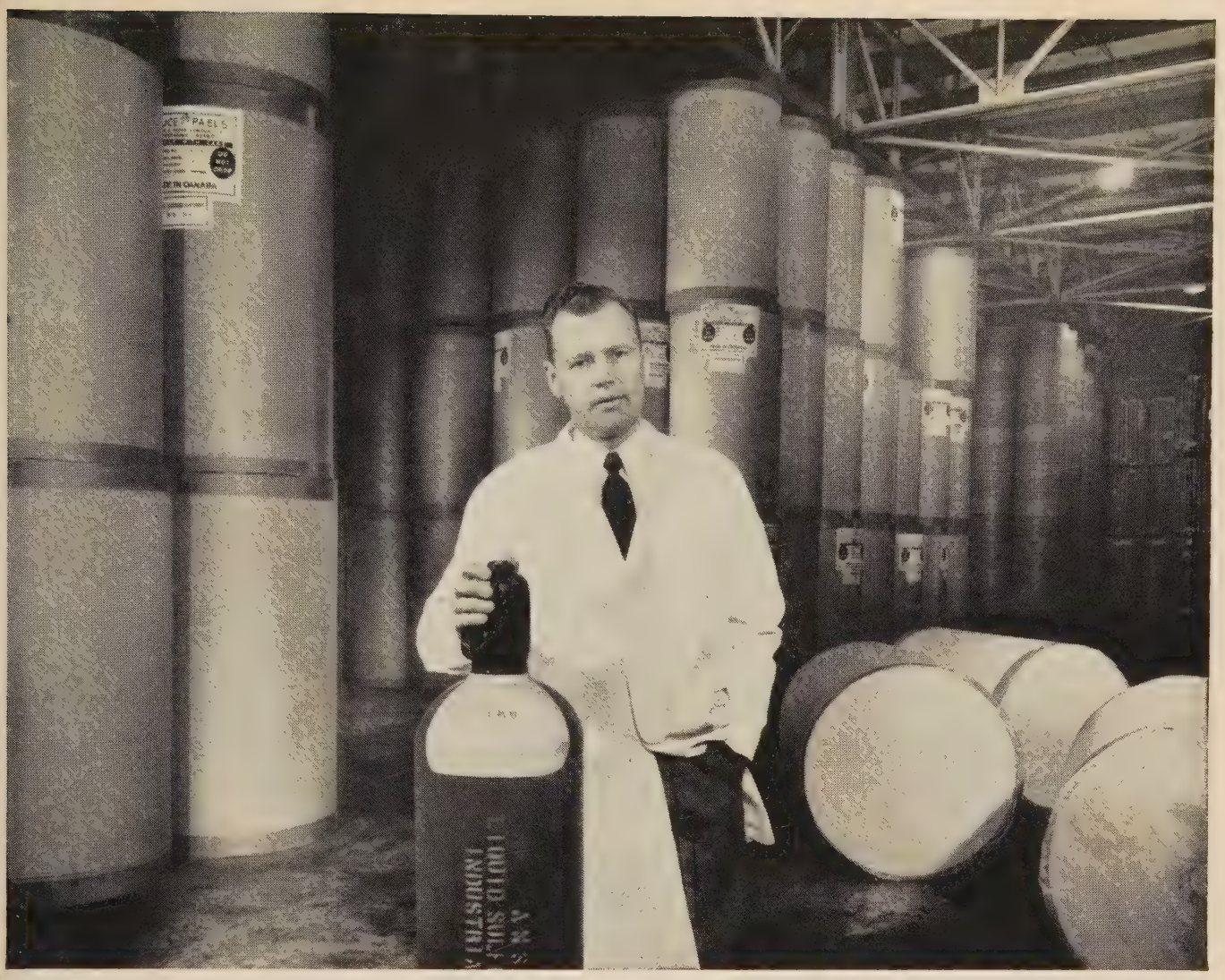

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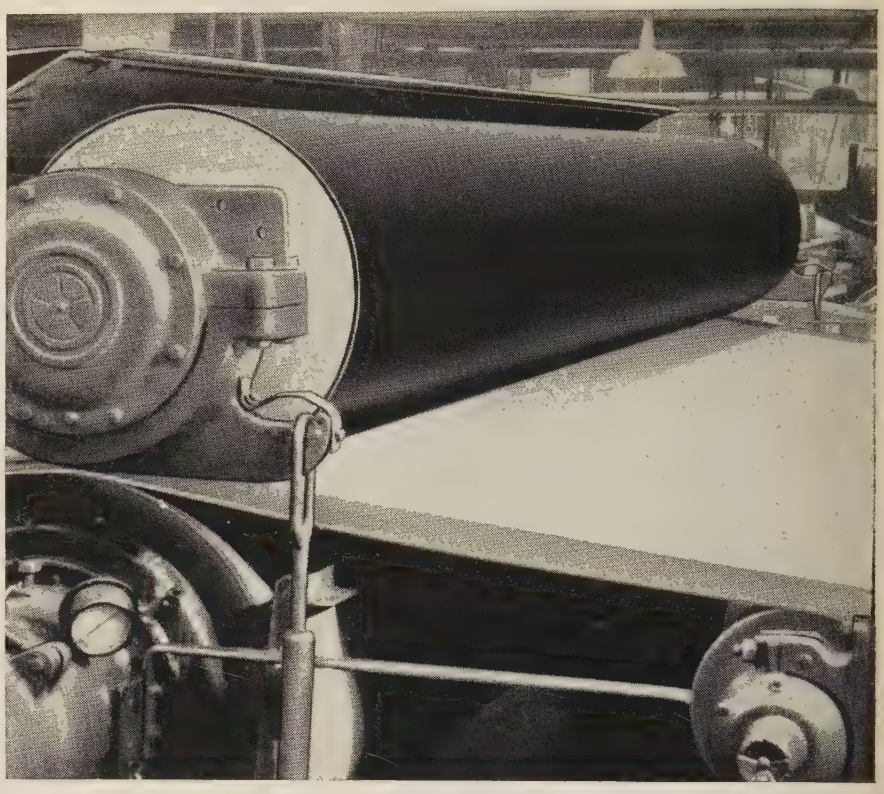

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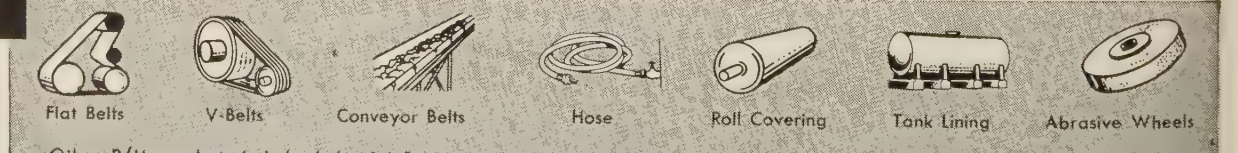

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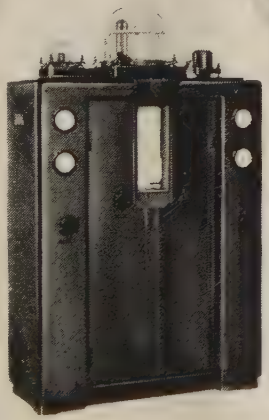

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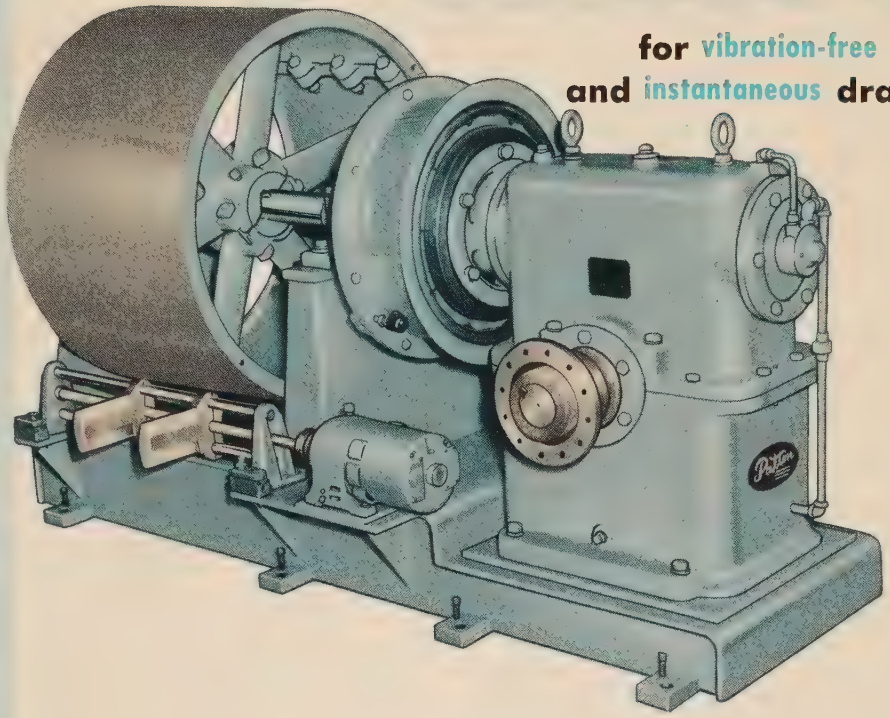

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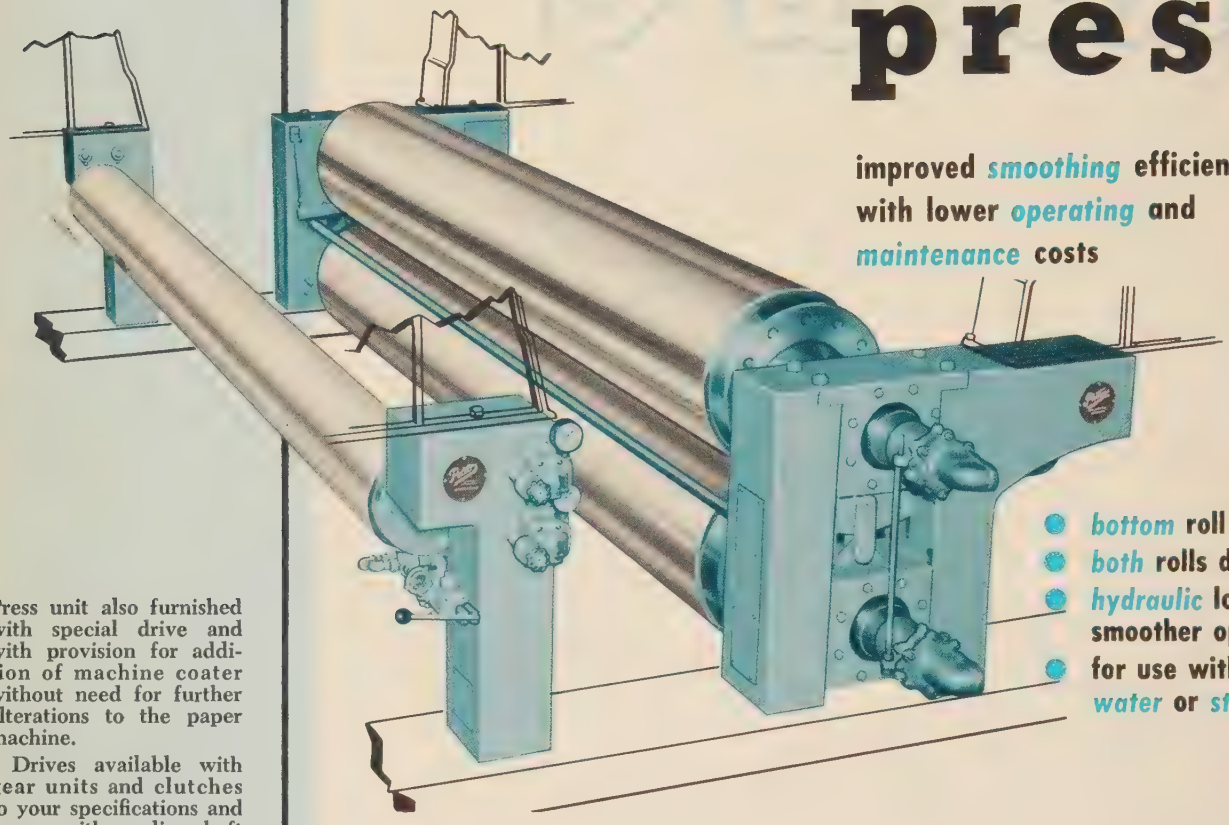

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Magnetic Amplifier Regulated Drives in the Paper Industry

M. H. FISHER

Static components have established a good reputation for reliability in electrical control systems. Since the magnetic amplifier uses only static components it is a natural choice when applying closed loop regulators in a paper mill. The principles of operation and the output characteristics of magnetic amplifiers are given. Sectional electric drives for paper machines have certain advantages and stable high-gain control systems have been developed. The application of magnetic amplifiers in combination with other units of the control system provides a speed regulation of highest accuracy and reliability. This application is described in considerable detail and the advantages cited. Also discussed are the regulators for helper drives, single motor drives, center-wind reels, supercalenders, and winders. Over 100 applications of these regulators have been made and over 50% are operating successfully.

Reliability is the most sought after quality in electric controls for paper mill use. Generally speaking, as system complexity increases, system reliability decreases. A control system may be broken down into major components each of which has a certain reliability as a whole component. These major components again can be broken down into minor or basic components. An example of a major component would be a magnetic control panel with contactors, relays, and resistors as minor components. The system reliability is related first to the reliability of the major components functioning as a unit and also to the minor components each of which is a link in the reliability chain. Static components have established a good reputation for reliability. Resistors, transformers, reactors, capacitors, and dry-type rectifiers are examples of static electric components enjoying a reputation for good reliability. For the reasons given above, it behooves the control engineer to use first, the minimum number of components, and second, the most reliable components available to him.

Demands for increased product quality and quantity have led to increased speed and size in production machinery. To meet these needs electric drive manufacturers have developed systems having increased accuracy and power using closed loop control systems. Closed loop control systems contain regulators and operate over their entire output range in a smooth and continuous manner. The number of components are minimized. The magnetic amplifier which requires only static components provides the utmost in reliability and is, therefore, a natural choice when applying closed loop regulators in a paper mill. Reliability of performance has been established by over 100 successful applications of magnetic amplifiers in the paper industry alone. Applications in steel, rubber, textile, material handling, and other industries have given reliable performance commensurate with the manufacturer's best expectations.

M. H. Fisher, Manager, General Mill Section, Industry Engineering Dept., Westinghouse Electric Corp., East Pittsburgh, Pa.

Many articles have been prepared discussing the theory of operation of magnetic amplifiers, so only a short review of the principles of operation will be undertaken here.

The chief components in a magnetic amplifier are saturable reactors, dry-type rectifiers, and resistors in the proper circuit arrangement. Sometimes capacitors and damping transformers are used for feedback and anti-hunting purposes. Small d.c. signals cause saturation of reactors which in turn control large blocks of power, thereby providing the high order of amplification required for satisfactory operation of closed loop regulating systems.

The principles of operation of saturable reactors have been known for a long time. The development of magnetic materials having square shaped hysteresis loops and high quality dry-type rectifiers along with circuitry developments made the final development of the magnetic amplifier possible. Since all components used are static and have long-standing reputations for dependability, it is not surprising that the major component (the magnetic amplifier itself) has established a reputation of high dependability.

All magnetic amplifiers utilize two reactors in circuitry designed to permit cancellation of the fundamental and the odd harmonic voltage waves induced in the control windings. The magnetic amplifier circuit known as the doubler circuit has proven to be one of the most satisfactory circuits for working into inductive loads such as the fields of d.c. rotating machines. The doubler circuit consists of two separate cores with load windings, control windings, and a self-saturating reactor for each core and a bridge-type complementary rectifier to supply direct current to the load. The circuit is arranged so that one core conducts while the other is cut off for alternate one-half cycles of supply voltage. Since only the voltage drop in the load winding of the reactor appears as back voltage across the saturating rectifiers, only a few high-quality cells are needed. Amplification without feedback is related to the quality of these rectifiers and the *IR* drop of the load winding. The back leakage of the bridge-type complementary rectifiers does not affect the magnetic amplifier performance, thus commercial quality rectifiers can be used.

A curve showing the relationship between the load voltage and the control ampere turns for the magnetic amplifier is known as the transfer curve or characteristic. Usually when there are no control ampere turns, the output is maximum. The curve is easily displaced by use of negative bias ampere turns which have the effect of shifting the transfer curve to the right so that the output is minimum at zero control ampere turns. Note that the output of the magnetic amplifier is never zero volts. This is due to the fact that there is a magnetizing current required in the load winding to overcome the reluctance of the magnetic circuit. The use

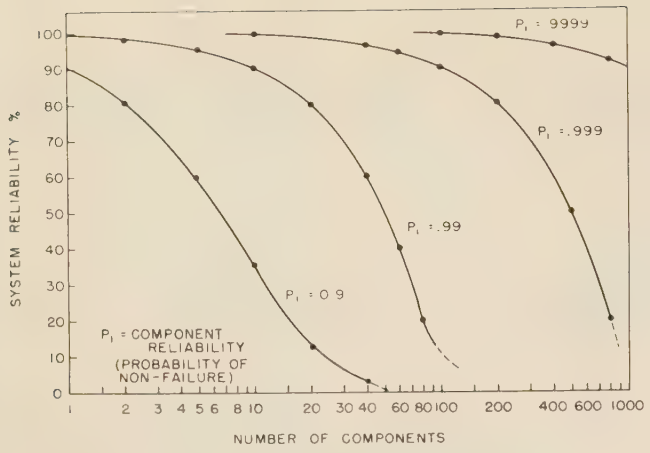

Fig. 1. System reliability curves

The Individual Component is the Cornerstone of System Reliability. Generally speaking, as system complexity increases, system reliability decreases. Reliability also depends strongly on the reliability of individual components, each of which is a link in the system chain. The accompanying plot shows that a system made up of ten components (each of which has a "probability of success" of 0.99 for a given set of conditions) has an over-all reliability of 90%. If under the same conditions, the system depended on operation of 20 components, reliability would drop to 78% and with 40 components to 60%. On the other hand, increasing component reliability of the 10-component system to 0.999 (one failure per thousand) increases system reliability to 99%. Raising component reliability by one "decade" (from 0.99 to 0.999) allows ten times as many components to be used in the system without increasing over-all failure probability.

In the curves shown, it is assumed that all components are equally reliable and that system failure is caused by failure of any single component.

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of gapless steel cores and good saturating rectifiers minimizes this effect.

Industrial regulators of the closed loop type require system amplifications ranging from 5 to 100 according to the system and the individual requirements of the drive. Magnetic amplifier response time of 3 cycles have been achieved (0.05 sec. on a 60-cycle power supply). Response time or time constant of a regulator is usually short as compared to the time constant of the electrical machinery and the mechanical system being driven. Therefore, regulator response is important only to achieve a stable system with adequate forcing.

Now that the theory of operation and the output characteristics of the magnetic amplifier have been briefly discussed, some of the applications in the paper industry can be examined.

SECTIONAL PAPER MACHINE DRIVES

To the electrical engineer the most interesting and challenging drive used in the paper industry is a sectional electric paper machine drive. Production and profits are directly tied to the machine availability and performance; therefore, management's eyes are always focused on the paper machine. Electric sectional drives have certain advantages such as:

1. Higher overall "machine productive efficiency" achieved with sectional electric drive. Sectional drive limits "out of service time" to a minimum because numerous wearing parts are eliminated. Maintenance of wearing parts such as clutches, belting or power size mechanical speed changers, complicated gearing, complicated lubrication systems, and numerous bearing seriously affect productive efficiency.
2. Highest speeds to date on paper machines are being attained with electric sectional drives.
3. Section loads are easily determined by ammeters. Effect of the load on paper quality and effect of such variables as pressure, vacuum hot bearings, and out-of-round rolls are readily recognized.
4. Smooth starts are assured with controlled torque as required by individual sections.
5. Sections are easily and smoothly operated, started, stopped, inched, and reversed and braked independently with the same drive equipment.
6. Electric sectional drives are complete machine drives without auxiliary driving equipment.
7. Wide draw adjustment of $\pm 12^1/_2\%$ permits compensation for machining of rolls without changing equipment. Draw adjustments are directly proportional to movement of draw adjusting mechanism which permits extremely accurate draw adjustment.
8. Electric drives are advantageously applied on top rolls, suction pick-up, wringer rolls, section couch and calender drier drives, regardless of whether basic drive is sectional electric or mechanical. Auxiliary drives on these rolls are simpler and less expensive when applied to electric sectional drives.
9. Future additions and modifications can be made more simply and less expensively. Speeds can be increased and sections can be added or re-arranged without changing the drive basically.
10. With the differential error detector and magnetic amplifier, very high accuracy of section speed is provided—well within the requirements of machine operation.
11. Efficiency of sectional electric drive is better by about 10% than lineshaft drive.

Engineers have been able to produce high gain and stable control systems for sectional paper machine regulators. However, accuracy of control depends on more than just a stable high-gain amplifying system. A standard for comparison as well as an accurate means for measuring the regulated quantity is also required. Accuracies in the order of $\pm$ 0.1% or better are absolutely necessary for "section to section" regulation. Use of a position matching system having both position and speed signal output in combination with magnetic amplifier regulators provides a speed regulating system having the highest qualities of reliability and accuracy yet achieved.

Reliability of the position-type magnetic amplifier sectional electric paper machine regulator has been demonstrated by an accumulation of 290,000 section operating hours on 35 units. This performance is equivalent to 99.945% availability of a six-section

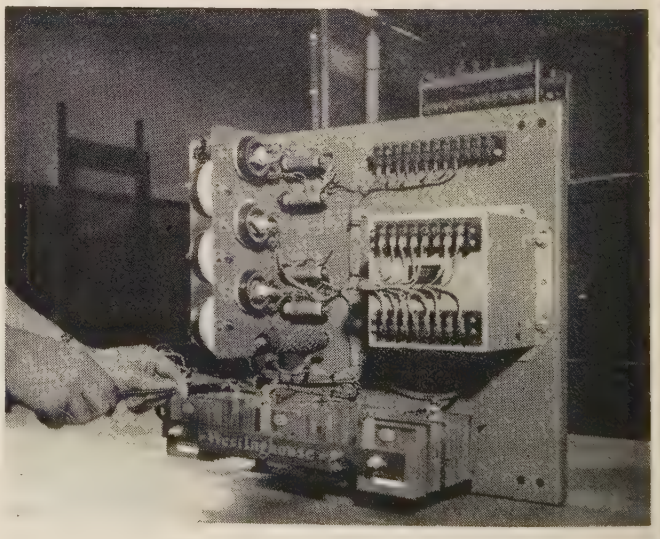


Fig. 2. Magnetic amplifier panel showing reactor, dry-type rectifiers and calibrating rheostats, and resistors

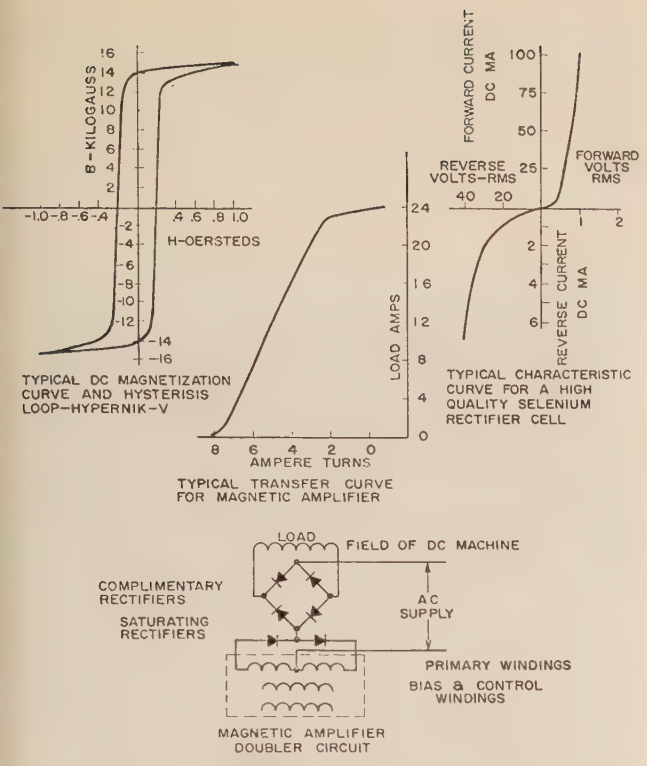


Fig. 3. Magnetic amplifier doubler circuit with typical transfer curve and characteristic curves for square-loop iron and high quality selenium rectifier

machine operating a 5.7-year period with 24 hr. per day use considering down time caused by the regulator including the differential mechanism. Down time caused by the differential mechanism itself has been less than one half of this amazingly low loss of production. In the accumulation of the above operating experience, no cases of draw variation other than those purposely made for production reasons were experienced.

High accuracy is one of the inherent features of the position matching speed regulating system. A continuous measure of relative position of each section with respect to the position of the master set is achieved, as described later. The relative position error signal is

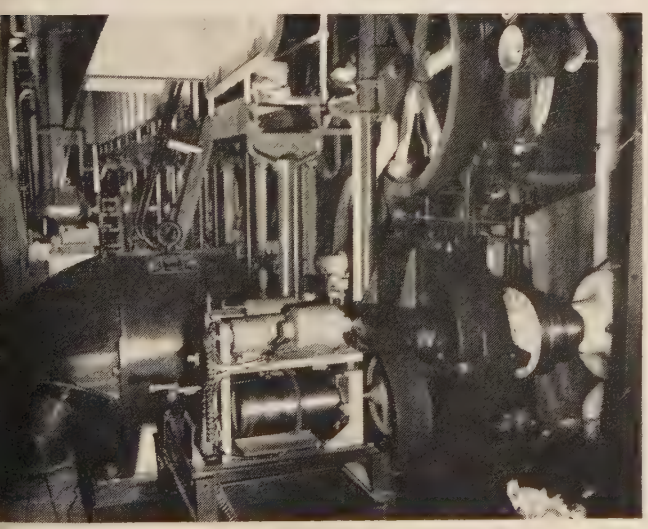


Fig. 4. Close-up view of calender section regulating unit; cover of position regulator is removed and d.c. tachometer, position rotary transformer, draw adjusting synchro and synchronous motor on top

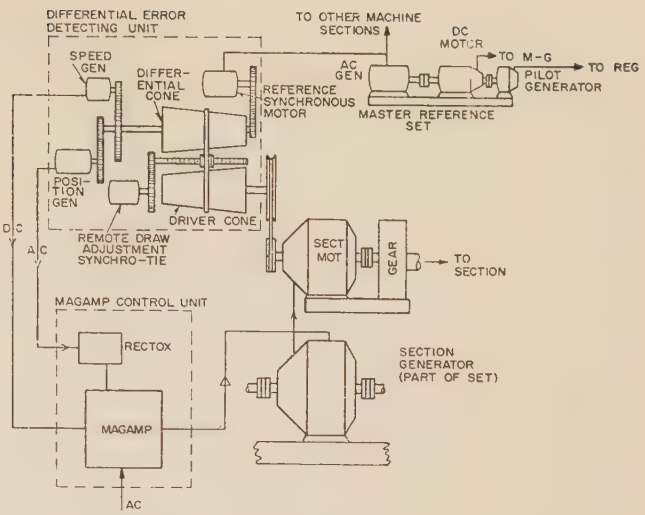


Fig. 5. Arrangement of components for a position-type speed matching regulator system

amplified by the magnetic amplifier and the amplified signal corrects the error which is angular in nature. Thus after a load change has occurred and a steady state condition reestablished, there is no speed difference error.

The position speed-matching system utilizes the adjustable frequency output of a small alternator on a master set as a standard of comparison. The master set consists of a d.c. motor driving an alternator. The speed of the master set is adjusted by the operator. Its speed is directly proportional to the required operating speed of the paper machine. This speed is maintained by regulating equipment which holds the speed constant with variations in supply voltage, ambient temperature and load. Regulation of the set and overall speed of the paper machine is not as critical as the speed regulation among the sections, but as previously mentioned, it is desirable to hold the overall speed close to $\pm$ 0.1% over the operating speed range to maintain proper quality control. The adjustable frequency supply from a master set is used to power small synchronous motors, each forming a part of the differential error detecting unit on regulated sections of the machine.

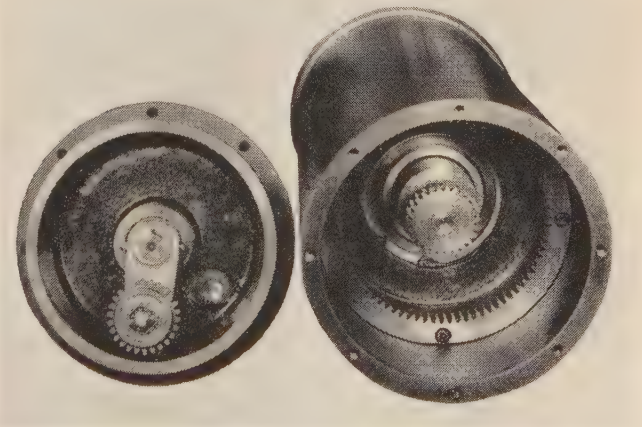


Fig. 6. Disassembled view of draw adjusting cone pulley showing error-detecting differential unit; ring gear is driven by section; center gear is driven by master set frequency supply; planetary gear turns on its own shaft during steady-state operation and turns in space relation when a speed error occurs

The error detector unit consists of a cone pulley driven by the regulated section motor. The driven cone pulley is belted to a second cone pulley in which the ring gear of the mechanical differential is located. A ± 12½% draw adjustment is provided in the taper of the cone to adequately take care of draw adjustment requirements and reduction of roll size due to machining.

The sun gear of the mechanical differential is driven by the synchronous motor which receives its frequency from the master set. The planet gear, located on the differential arm, turns on its own bearing during the steady state operating conditions but turns in space relation only when making an error correction. The differential output shaft is positively connected to both position and differential speed cueing devices. The position sensing device is a small rotary transformer

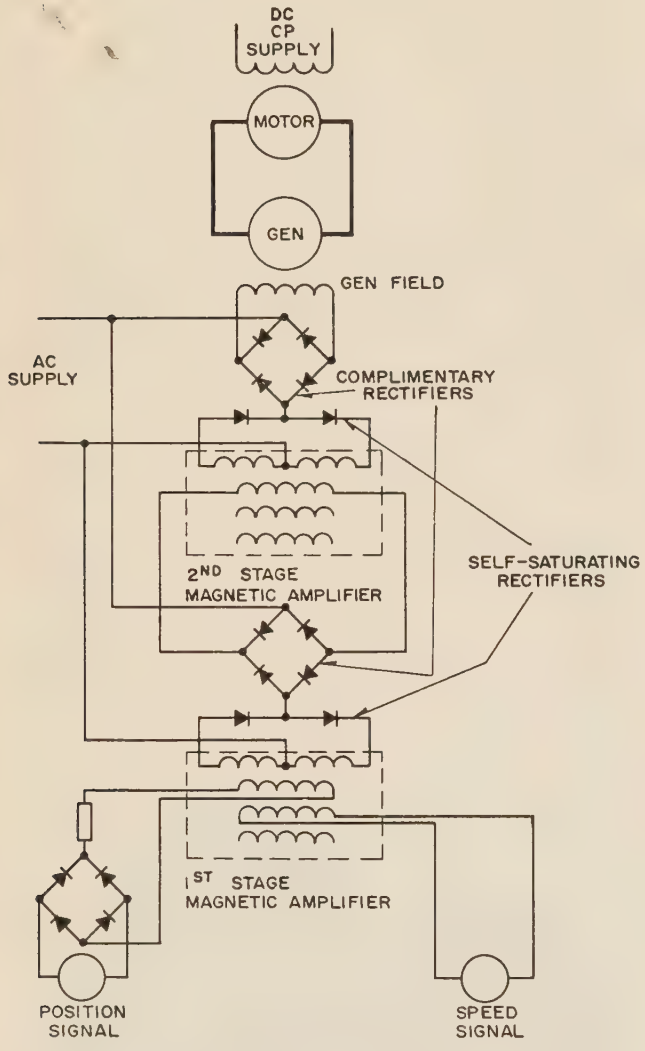


Fig. 7. Schematic diagram of magnetic amplifier regulator using both position and speed signal for high accuracy and fast speed of response

similar in operation to an induction regulator, and it produces a signal proportional to its rotor position. A set of stops with a small slip clutch are mounted on the rotor shaft of the rotary transformer to limit the rotor travel to about 55 electrical degrees or less for the regulating range.

The differential speed cueing device is a small d.c. generator which produces a signal voltage proportional to the speed of movement of the differential crank arm.

The rotary transformer and d.c. generator are in motion only during the correction period. Under normal running or steady state conditions the only

Fig. 8. Cubicle containing magnetic control and magnetic amplifier regulator used with position speed matching system

moving elements of the regulator are the cone pulleys and the synchronous motor.

Draw adjustment is accomplished on the tending side of the machine by adjusting the position of a spring tensioned belt that connects the two cone pulleys. Slack take-up may be accomplished by means of push-button operated magnet coils that allow a momentary shift of the cone pulley belt.

The two signals (namely, the position and the differential signals) produced by the error detecting unit are fed through the closed loop regulator which contains two stages of magnetic amplification. The first stage amplifies the electrical signals from the error detecting unit, and the second stage furnishes controlled excitation to the shunt field of the regulated generator (or motor in the case of single generator drive). The regu-

lator includes control transformers, selenium rectifiers, calibrating resistors, and damping transformers to assure stability for this high gain regulator. The constants of the regulator are so designed that the speed signal amplification is high as compared to the position signal amplification. Thus, when load change occurs, considerable forcing is obtained to restore the regulated

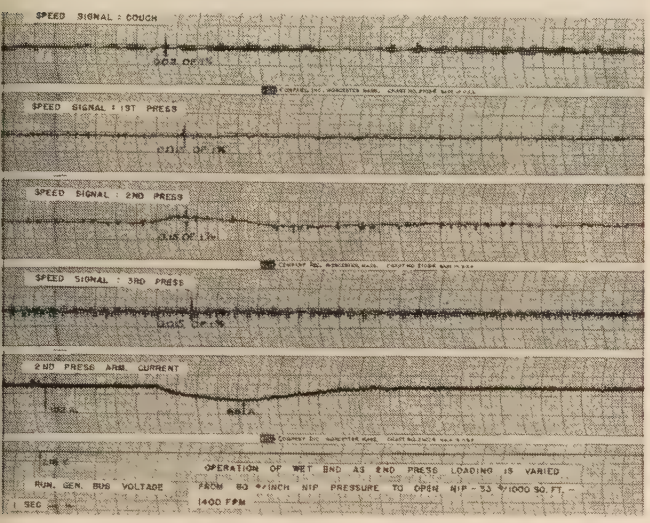

SPEED SIGNAL : COUCH
SPEED SIGNAL : 1ST PRESS
SPEED SIGNAL : 2ND PRESS
SPEED SIGNAL : 3RD PRESS
2ND PRESS ARM. CURRENT
OPERATION OF WET END AS END PRESS LOADING IS VARIED
RUN. GEN. BUS VOLTAGE
FROM 80 #/INCH NIP PRESSURE TO OPEN NIP - 33 #/1000 SQ. FT. -
1400 FPM
1 SEC

Fig. 9. Performance curves for magnetic amplifier position-type regulating system

section to its original speed. A 400 cycle a.c. power supply for the magnetic amplifier can be used to minimize the sizes of the reactors and to insure fast response.

Position speed-matching regulators have been used in the electrical regulating circuits for more than 30 years. Previously, the mechanical differential worked into a variable resistance. Circuit amplification was low, and there was little forcing effect. Such regulators were considered satisfactory in their time. Production requirements in the modern paper mill demand improvement in paper quality as well as improvement in the machine drive efficiency. More amplification and forcing effect are necessary to obtain the accuracy and response commensurate with the requirements of modern paper machines.

With the mechanical magnetic amplifier speed-matching system of control, following a load change, the output shaft of the error detecting unit will assume a new angular position and the paper machine section must change its angular relation to the other sections. The sections are actually locked together in angular position by the regulator. Any position error is not cumulative, and once a new angular position is assumed, the rolls must maintain exact relative speeds with respect to each other.

Changes in amplification in the position signal circuit will cause the error detector to operate at a modified position, but the steady state accuracy of the regulator will not be affected. Changes in amplification in the speed sensitive loop will cause a variation in the forcing effect of the magnetic amplifier regulator circuit. The time of response to load change only will be affected. In this connection, variations as great as ± 25% in gain will not seriously affect operation of this regulator. Since such amplification variations are not encountered in the magnetic amplifier regulator, this permissible wide variation of amplification assures optimum regulator performance without a special maintenance program.

With the mechanical differential speed regulator, the operator may be assured that the regulator is operating satisfactorily when the rotary transformer is in the central region of its range and there is no motion of the differential output shaft. If, on the other hand, the position transformer is at either end of its range or a motion is observed on the steady state load conditions, there is indication that the regulator is improperly adjusted. This allows the machine operator to check the regulator performance without the assistance of the electrical maintenance man.

Plus features of the position-type signaling device working into a magnetic amplifier include the fact that the changes in output of the position speed signal caused by such things as changes in ambient temperature, exciter voltage variations and brush seating may affect system amplification to a small extent but they do not affect accuracy of the regulated system.

On the paper machine, under normal operating conditions, section load variations are rarely encountered.

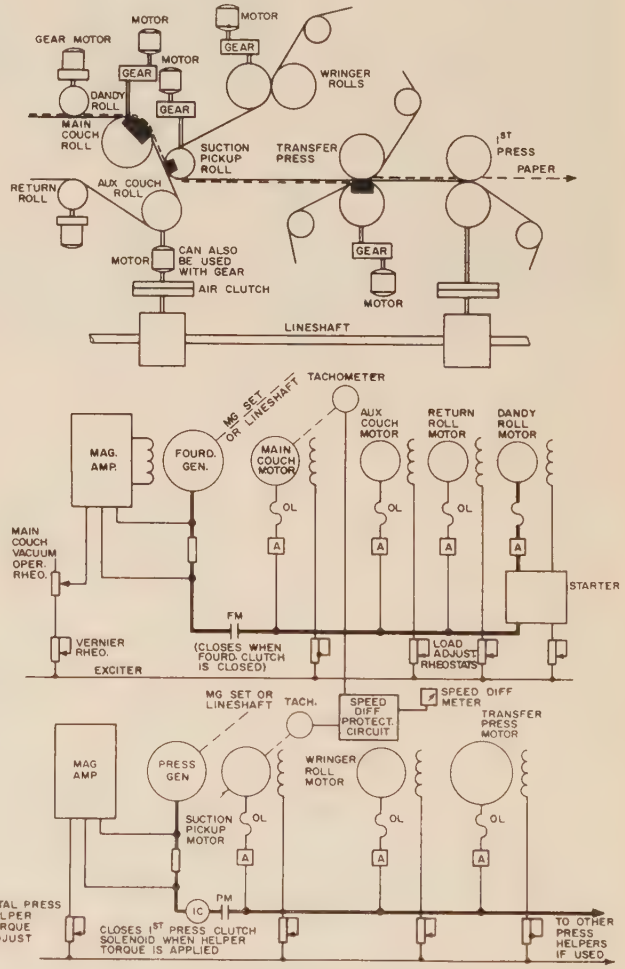


Fig. 10. Typical fourdrinier helper drive system for a lineshaft driven machine with a suction pick-up roll

Important load variations include those incurred as follows: (1) when stock is put on the fourdrinier section; (2) when the press nip pressure is varied; (3) when a snap-off occurs between the calender and driers.

Test results demonstrate that the position-type magnetic amplifier sectional paper machine regulator has

Fig. 11. Shop view of magnetic amplifier control panel for a large fourdrinier helper drive; magnetic amplifier on right provides torque regulation for entire press drive; magnetic amplifier on the left provides torque regulation according to the vacuum on the main couch roll; electronic device in the center is a super-sensitive speed match indicator for matching the speed of the fourdrinier wire and the vacuum pick-up roll

adequate field forcing and anti-hunting characteristics to hold draw variations between sections within permissible limits during transient disturbances. After disturbances, stability is quickly re-established.

As paper machines become wider and faster, greater frequency of paper grade changes are encountered. For this reason and others such as sheet quality adjustments, the overall machine speed must be adjusted. Ability of the regulator to cause the machine sections to maintain their relative speeds during acceleration, as well as after the speed change is complete, is called "tracking" ability. During speed change periods, the problem is the same with all types of regulators and a

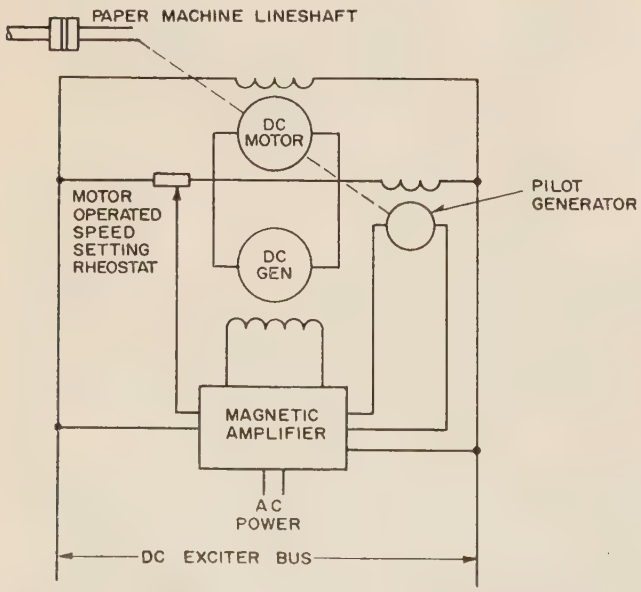


Fig. 12. Simplified diagram for a single motor drive

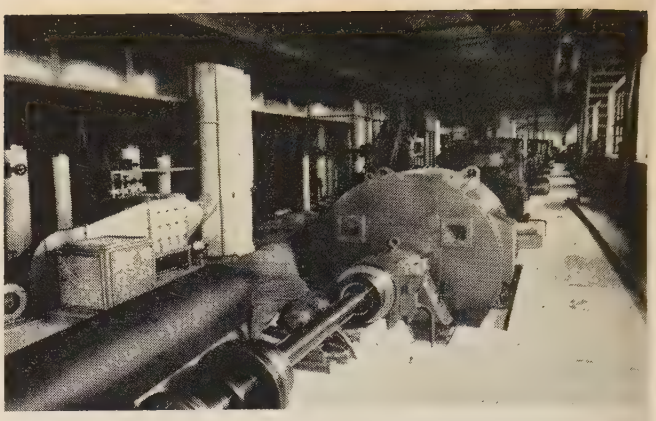


Fig. 13. 1250-hp., 1000-r.p.m., single motor drive for a 2000-f.p.m. paper machine

high gain system such as provided in the speed signal system of the position-type magnetic amplifier regulator minimizes speed variation. After the speed change is complete, since the position-type regulator is not satisfied until there is zero speed error, the relative speeds of the sections will be the same as before the speed change was made.

HELPER DRIVES

Regardless of whether a modern, high-speed paper machine is driven by an electric sectional drive or a mechanical drive, the characteristics of the forming section dictate that the power be put in at several points on the felt or wire to increase life and to aid formation. On some of the latest fourdrinier machines, use is made of a suction couch and a wire turning roll at the exit end of the fourdrinier wire. Both of these rolls are driven. On a section electric drive the wire turning roll drive motor is speed regulated. On a mechanical drive the wire turning roll is driven by the lineshaft, and on the larger paper machines due to limited torque

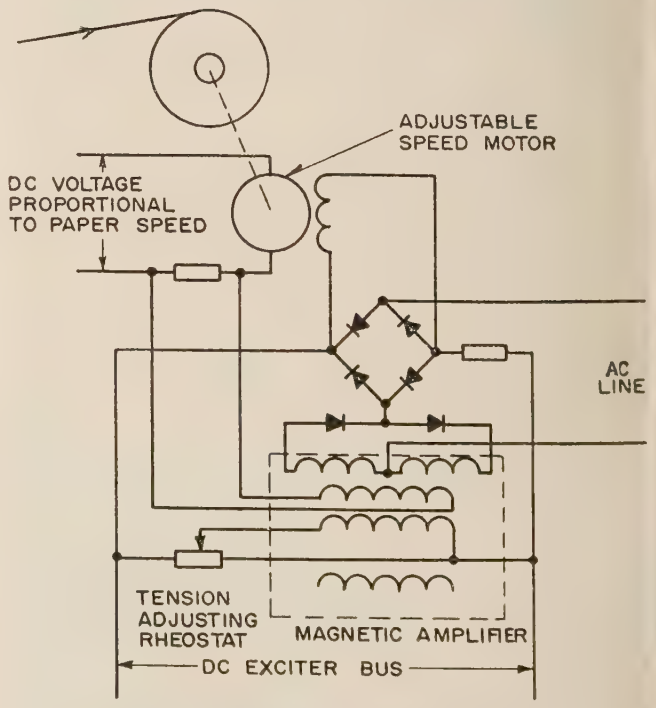


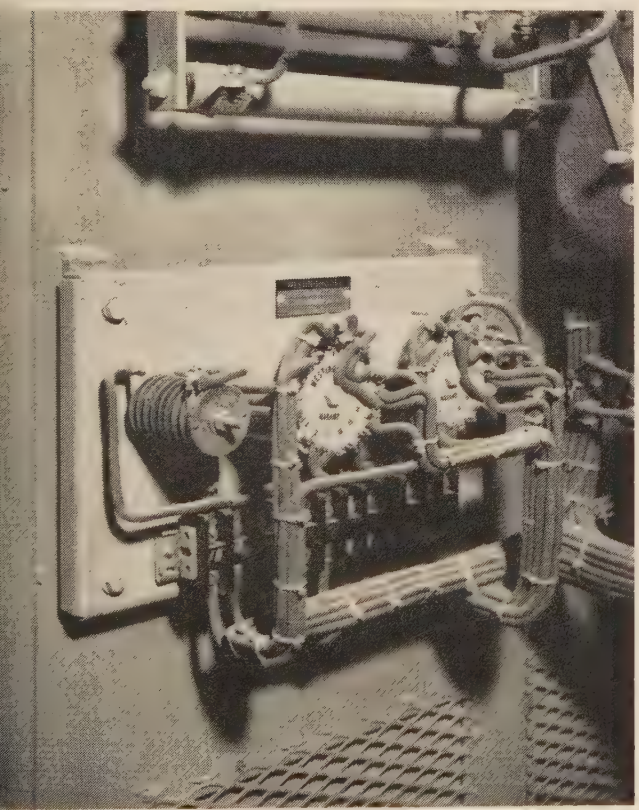
Fig. 14. Magnetic amplifier regulator system for a center wind reel

vailable from the mechanical system, a helper with a orque regulator is provided for the couch roll.

Since the torque of a d.c. motor is directly proportional o current, if flux is held constant, a simple current regu- ator is provided. Several applications of magnetic mplifiers to regulate current as set by the operator have been installed, with excellent results.

A regulator for regulating torque exerted by the suc- ion couch roll is not so simple since the fourdrinier only vraps the couch roll for about a 30° span. It is desir- ble to put from 50 to 70% of the section power require- nents in at this point, but wire slippage would occur if ull torque were applied before the sheet is across and he vacuum is established in the suction-type couch oll. Therefore, torque must be regulated proportional o vacuum. A vacuum controlled regulator is provided vhich cues a magnetic amplifier to regulate couch motor orque according to couch vacuum.

Cylinder molds on cylinder machines as well as press elpers for both cylinder and fourdrinier paper machines re regulated to provide constant helper torque over he speed range as adjusted by the operator. Power s supplied to these helper drives from d.c. generators vhich may be driven from the lineshaft or which may e part of a motor-generator set. Location of the enerator may be dictated by the adequacy of power



ig. 15. Magnetic amplifier paper break detectors; when paper break occurs, a large reel is apt to be out of bal- nce; this device detects the rapid change in field current and shuts the reel down

apacity to drive the lineshaft or by system preference n the part of the customer.

Magnetic amplifier regulators are provided to regu- ate total current for a single motor or group of motors nd, as pointed out above, since torque varies as current f field flux is held constant, such a system regulates torque. Torque is divided among the section motors as adjusted by a rheostat in the individual motor shunt field circuit.

Torque for aiding breakaway and acceleration of the section to which the helper motors are applied is provided by the control system. This prevents a section

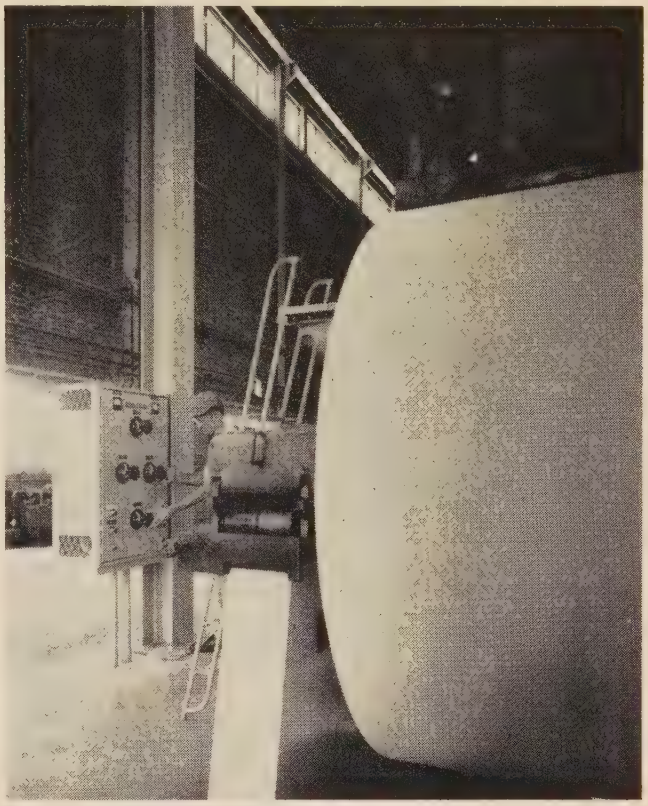


Fig. 16. Operator's control station for a two-high core type reel drive; the 15-h.p. adjustable speed gearmotors hold constant tension while the reel diameter changes over a 5.25 to 1 range

felt from being unduly strained during the breaking away and accelerating periods.

SINGLE MOTOR DRIVES

Lineshaft driven paper machines are powered mainly by adjustable speed turbines or by single motor paper machine drives. The drive selection is dictated by the particular heat balance problem existing in a given mill. Recently, consulting engineers have been of the opinion that it is more economical to put the steam driven equipment in the power house and drive all process machines with the electric power.

During the past year, four single motor drives varying in capacity from 350 to 1500 hp. were supplied using magnetic amplifier type of speed regulators. Speed of the paper machines vary from 500 to 2000 f.p.m. maximum and various grades of paper varying from saturating pulp to newsprint are to be made by the paper machines.

A speed regulating system, as used for single motor drives, is required to maintain high accuracy during load changes. A requirement that is even more exacting, however, is that of holding constant speed over long periods of time, thus insuring minimum variation in paper quality.

A speed regulating system utilizing a pilot generator

to measure speed, a magnetic amplifier regulator to regulate speed, and with all speed control being obtained by voltage has proven to give maximum dependability by virtue of its simplicity. This system maintains a constant revolution per minute speed accuracy over the operating range because it is sensitive to a fixed change

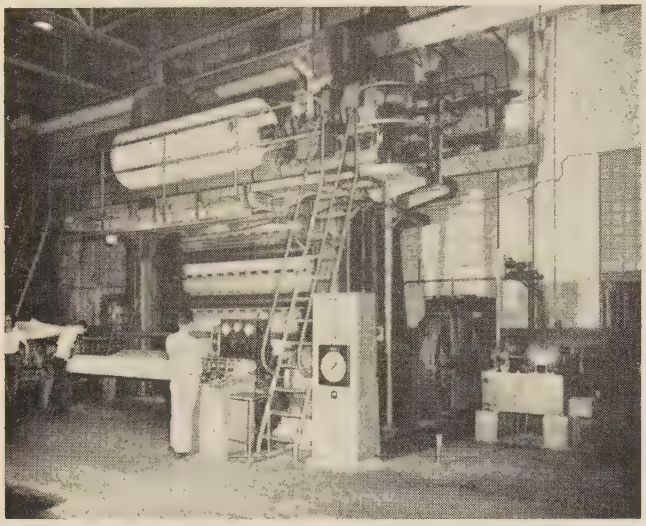


Fig. 17. Installation of a large high-speed supercalender; note the use of low speed braking generator and low speed wind motor which assure more accurate sheet tension since mechanical losses are minimized

in pilot generator output voltage. An accuracy of ± 0.25% at the top operating speed is normally considered adequate for single motor drives, although better accuracy can be provided if required. To minimize speed changes over a long operating period (24 hr. or more), special provision must be made to reduce the effects of ambient temperature variation and exciter voltage variation. The speed regulator for a single motor paper machine uses a self-compensating pilot-generator circuit to minimize these effects. The pilot-generator itself is a special machine that has restricted armature endplay, and a special frame and poles to reduce hysteresis and residual-magnetism effects. It is operated over a straight line part of its saturation curve so that its output voltage changes in exact proportion to its field current. Its field is in series with the speed-control rheostat so that changes in excitation affect the cue voltage across the rheostat and the output of the pilot generator by proportional amounts. Thus, the circuit is self-compensating and assures constant speed control over long periods of time.

CENTER-WIND REELS

Center-wind or core driven reels are provided on many paper machines. Core driven reels are powered by d.c. motors with wide speed adjustment by shunt field control. When the paper is made at constant rate of speed, the reel diameter builds up from empty core to full reel necessitating that the reel motor slow down. The reel motor receives its power from the generator whose output voltage is approximately proportional to the linear speed of the paper. When constant tension regulators are applied on these applications, the reel motor shunt field is excited from two sources—the constant potential exciter bus through a series resistor which sets minimum field excitation and prevents loss of field and a magnetic amplifier which automatically adjusts the motor shunt field as reel diameter builds up. Since the motor armature voltage is constant and proportional to paper speed and the motor current is held constant by the regulator, the center-wind reel regulator functions as a constant horsepower regulator.

$$(HP = K\,[E \times I])$$

There is a limitation in the change in diameter that can be accomplished with the center-wind reel. This limitation is imposed by the speed range limitation by shunt field control on d.c. adjustable speed motors which is 6 to 1. Reel diameter beyond 6 to 1 can be accomplished in special cases, but such control is usually unduly expensive and variations from constant tension must be accepted or a mechanical tension measuring device used with its problems of physical interference and maintenance.

Sometimes it is desirable to achieve an automatic reduction in tension as the reel builds up. This is called tapered tension and this feature is desirable to achieve hard cores and loose outside layers to prevent rolls from telescoping. If a booster is placed in the center-wind reel motor armature circuit, the tapered tension effect can easily be achieved by reducing the motor terminal voltage as the reel diameter increases. This, in effect, reduces the motor horsepower as the reel increases in diameter and thus achieves reduced tension as the reel of paper grows larger.

An interesting and novel application of the magnetic amplifier is found on a paper break detector. When heavy paper such as saturating pulp is wound on a center-wind reel, the reel diameter may be allowed to build up to 96 in. in diameter from a 16-in. core. Considerable tension is held in the sheet, and if the sheet should break, the regulator will cause the reel motor to

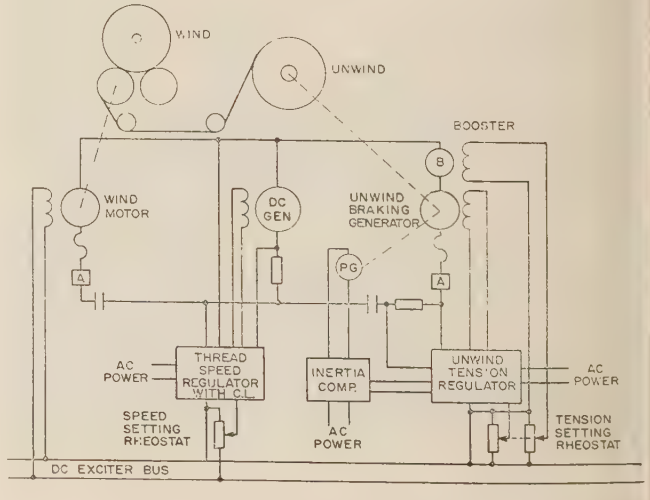


Fig. 18. Diagram of winder drive control system with unwind braking generator

accelerate the roll toward empty core speed. Such large reels weigh as much as 17 tons and are not in mechanical balance. If a large reel is accelerated, considerable damage could be initiated by the unbalance of the reel. A magnetic amplifier paper break detector is provided to sense a rapid change in the motor field

strength. This paper break detector initiates shutdown of the reel and prevents damage to the operator and/or machine.

SUPERCALENDERS

After certain paper such as book, writing, and glassine leaves the paper machine, they are taken to the

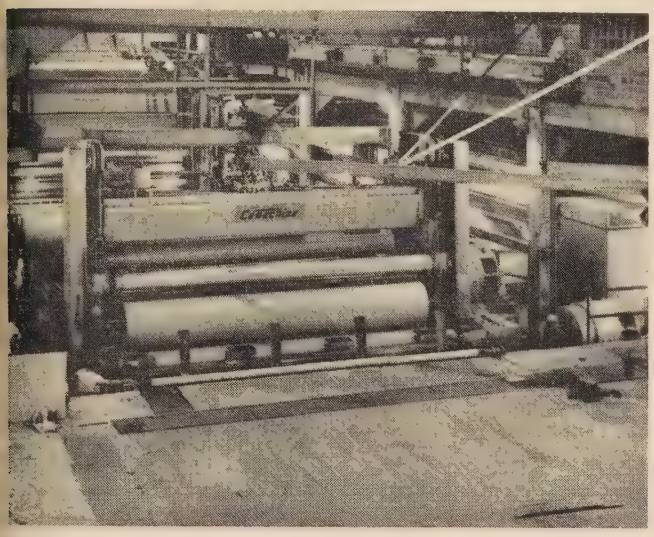


Fig. 19. 240-in. wide, 5000-r.p.m.-winder used to wind kraft board; note drive motor, braking generator, and magnetic amplifier control cubicle at right

supercalender to be given a hard surface. The supercalender is not a continuous process machine; and since its productive time is about 70% of the operating period due to threading, changing of reels, and splicing of sheets, the supercalender must be operated at the fastest permissible speed to get maximum production. Maximum speed is usually set by the heat dissipating characteristics of the softer rolls in the calender. As the speeds of paper machines are increased, the speeds of supercalenders have tended to follow; for example, the maximum speed of supercalenders in 1930 was 1200 f.p.m., by 1940 the speed had increased to 1500 f.p.m., and today 2000 f.p.m. is common. With all of this increase in operating speed, the threading speed has remained at 50 f.p.m. as the operator cannot conveniently thread at greater speeds.

Applications of pressure on the supercalender rolls can cause the calender to change from about 10 to 100% of the drive rated value. Unless the pressure can be applied at the threading speed and the calender accelerated with pressure on, then the paper processed during the accelerating and decelerating periods is off quality and must be scrapped. On a 2000-f.p.m. calender, about 660 ft. of paper would be scrapped, each time the calender is accelerated. To avoid this waste, the supercalender is equipped with a special speed regulator which prevents stalling and permits the application of full pressure at threading speed.

A precision regulator is not required, therefore, a counter-electromotive force type of speed regulator can be used to provide the treading speed regulation. A magnetic amplifier regulator is provided which will allow threading speeds as low as $^1/_{40}$ of top speed and application of 100% load at this speed with only a small change in paper speed.

The supercalender process requires that the paper be unwound under tension at the entry end and rewound under tension at the delivery end using core type reels. When electric reel drives are used, they are regulated to hold essentially constant tension in the sheet while at threading speed, during acceleration, deceleration and at any operating speed. Magnetic amplifier constant-tension reel regulators operate as constant horsepower regulators since they regulate to hold constant current by adjusting the motor shunt field strength as the reel diameter changes ($HP = K\ [E \times I]$). These constant tension regulators operate essentially the same as the center-wind reel regulator previously described.

In addition to holding tension, during the running period of the supercalender operation, the regulator must provide correct tension during the accelerating and decelerating periods. Inertia compensation is provided during the rate of change of speed period to insure correct tension. Experience has shown that most operators like an acceleration rate of about 50 f.p.m. per sec., and since such a slow rate of change is best provided by a motor operated rheostat, a constant inertia compensation signal is all that is necessary for the supercalender.

WINDERS

Winders following paper machines must operate at speeds exceeding two times the maximum speed of the paper machine which it serves. Winder speeds of

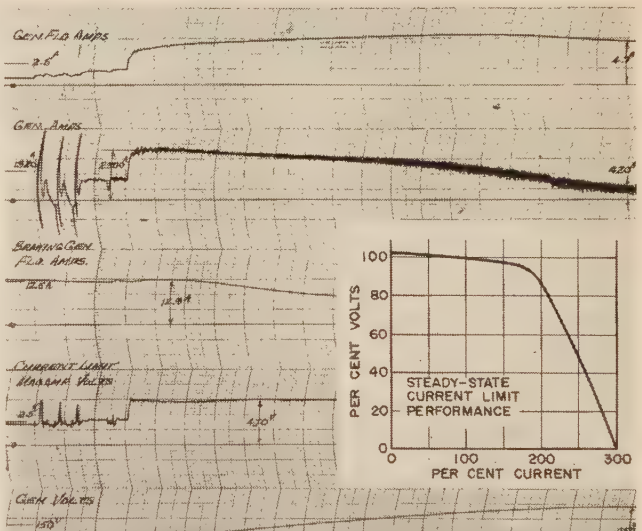


Fig. 20. Performance curves for winder drive of Fig. 19

5000 to 6000 f.p.m. are not uncommon these days. Acceleration and deceleration times must be minimized to obtain as fast a winding cycle as possible. Adjustable voltage electric drives are used on the modern high speed winder, because they have proven to be the most suitable for the application.

Operation dictates the winder be inched and threaded at a speed of about 50 to 100 f.p.m., acceleration to top speed, run until the shipping roll approaches desired diameter, and decelerate to complete stop. Acceleration rates on the heavier papers and boards are limited only by the overload ability of the electrical equipment, thus current limit acceleration and deceleration is desirable. A magnetic amplifier speed regulator to provide uniform threading speed is provided. This regulator is provided with current limit override to protect the electric equipment on acceleration and deceleration. A uniform threading speed and rapid acceleration and deceleration is required regardless of whether mechanical or electrical braking scheme is used.

Beyond the normal braking function, the electric brake on the winder provides the plus features of payout, slack take-up and stall tension. The tension provided by an electric brake is readily adjustable and all control is automatic over the operating speed range and during the diameter change. Inertia compensation is provided to maintain uniform tension during the acceleration and deceleration periods. The smooth and continuous operation of the magnetic amplifier is well suited to the job of maintaining winder tension.

On large winders power savings become appreciable when the electric brakes are applied. On large high-speed winders an annual savings of $5000 can be made by applying electric braking on the unwind stand. At the same time, the elimination of mechanical brakes materially reduces the maintenance cost on the winder and improves operating efficiency.

CONCLUSIONS

The papermaking process is a continuous one, often operating 7 days a week. Down time is expensive, so satisfactory regulators, minimum maintenance, and service continuity are most important. At this time, over 100 applications of regulators discussed in this paper have been made. More than 50% of these applications are installed and operating successfully. Equipment operators are enthusiastic and happy with the performance of these magnetic amplifier regulators. Magnetic amplifier performance has already demonstrated that it is the most maintenance-free and consistent amplifier system yet developed.

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An Evaluation of Various Beater Retention Aids for Titanium Dioxide Filler in the Presence of Chlorinated Corn Starch

HAROLD C. BRILL

Data based on laboratory handsheet evaluations are given to show that most commercial corn starches for beater addition are harmful to titanium dioxide retention. Chlorinated corn starch was found to be one of the most harmful. Paper manufacturers encounter chlorinated corn starch in their beaters because it is added for bursting strength improvement, from coated paper broke, or waste-paper addition. The effects of basis weight, pre-flocculation of pigment, alum, sodium aluminate, sodium phospho aluminate, animal glue, diatomaceous silica, Idaho potato starch, and cationic starch on the retention of titanium dioxide in the presence of chlorinated corn starch were investigated. Under the conditions of the test, sodium aluminate and cationic starch gave the best results.

Various starches have been used for many years as beater additives to improve the sizing of paper and increase the physical strength. The starch has been added in the form of a cooked slurry, as a dry cold water-soluble starch, or in the form of a dry powder which is retained in the sheet in a similar fashion to clay and then is gelatinized on the drier stacks. Many types of starch are used such as corn, potato, or tapioca. Starch producers have special beater starches that are cold water soluble or modified various amounts by chlorination, enzyme conversion, or acid modification. A method of depositing pearl corn starch on paper fiber through the use of soap and alum is also used in the paper industry.

Titanium dioxide is frequently used in the lighter weight papers to supply brightness, printing opacity, or waxed opacity to bread wrap, catalog, glassine, and Bible papers. The substitution of inert filler for fiber will frequently cause a noticeable drop in physical strength. It is customary in some of these papers to introduce starch at the beater with the titanium dioxide to correct this loss of strength.

Before proceeding with a discussion on the effect of starch on the retention of titanium dioxide in the beater, we should like to define what we mean by retention. E. Sutermeister in his Book, "Chemistry of Pulp and Paper Making," defines retention as: "The percentage of the filler added to the furnish which appears in the finished paper." The discussion of retention may be divided into two types; namely, retention of filler after one pass through the wire and the over-all retention where a white water system is employed. One-pass retention is of great importance to specialty mills where a large number of different grades of paper are produced both with and without titanium dioxide. If a nontitanium dioxide grade must be scheduled after

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Table I. Beater Retention of Titanium Dioxide Filler in the Presence of Various Modifications of Corn Starch

No.	Supplier	Description	Starch o.d. basis, %	TiO_2 added, %	Retention, %	Ash, %	Bursting strength, p.s.i.
1	..	Control—no starch	..	None	..	None	10.5
2	..	Control—no starch	..	12.5	53	6.6	6.3
3	A	Corn pearl unmodified cooked	2	12.5	38	4.8	11.6
4	A	Corn pearl unmodified—dry addition	2	12.5	45	5.6	8.3
5	B	Corn pearl—slightly oxidized cooked	2	12.5	16	2.0	12.9
6	B	Corn pearl—slightly oxidized—dry addition	2	12.5	46	5.7	8.5
7	C	Corn ethylene oxide modified—cooked	2	12.5	28	3.5	11.6
8	C	Corn pearl—cooked—soap precipitated (*2*)	2	12.5	22	2.8	14.6
9	C	Corn pearl—enzyme converted	2	12.5	42	5.3	7.7
10	B	Corn-oxidized-flocculating—cooked	2	12.5	20	2.5	12.6
11	B	Corn-oxidized—cooked	2	12.5	17	2.1	12.9
12	B	Corn-highly oxidized—cooked	2	12.5	14	1.8	13.3
13	A	Corn—oxidized—cooked	2	12.5	14	1.8	13.6

Fifty-pound basis weight (25 × 40—500), bleached sulphite pulp, 32° Schopper, 2% alum, 2% rosin size.

a run containing the pigment, the titanium dioxide content of the white water system will be dissipated in upgrading a paper that cannot stand a higher price level. Frequently, mills do not have a white water system for each machine and will have two or more connected into the same reclamation system. Under conditions of this type, it is often necessary to schedule grades of paper, with and without titanium dioxide, on adjacent machines with the same white water return. Poor one-pass retention on the machine using pigment leads to wastage into the lower priced grade. The data given in this paper are solely one-pass retention.

THE EFFECT OF STARCH TYPE

There is considerable difference of opinion in the literature on the effect of starch in the beater on the retention of various fillers in paper. The discussion covered in this paper deals solely with the behavior of anatase titanium dioxide pigment. Willets (*1*) found that starch was definitely detrimental to the retention of this pigment and reported that certain starches were more detrimental than others. He theorized that the starch might be acting as a protective colloid and preventing the filler from being coagulated and fixed on the fiber. Table I gives the results of our comparison between different corn starches on the retention of titanium dioxide.

This study was limited to various modifications of corn starch and the following conclusions may be drawn:

1. All the starches, in all the modifications tested, reduced the retention of titanium dioxide.
2. Dry addition pearl starch reduced the retention of the pigment to the least extent.
3. The cooked, oxidized starches were some of the worst offenders in reducing the retention of the pigment.
4. The soap precipitated pearl gave the greatest physical strength improvement but some of the oxidized starches were very close seconds.

THE EFFECT OF STARCH QUANTITY

All of the work shown under Table I was done with a 2% addition of starch on the moisture-free pulp. Since many mills do not deliberately add starch to the beater but do encounter small amounts from coated waste paper or the return of broke from their coating operations, we investigated the quantities of chlorinated starch which might cause damage. Table II contains these data on a lightweight 25-lb. (25 × 40—500) bleached sulphite handsheet. The lighter weight was selected because retention of titanium dioxide is more critical in this type of paper.

Table II. Beater Retention of Titanium Dioxide in the Presence of Varying Amounts of Chlorinated Corn Starch

No.	Chlorinated starch, %	TiO_2, added, %	TiO_2 retention, %	Ash, %	Bursting strength, p.s.i.	TAPPI opacity, % Unwaxed	TAPPI opacity, % Waxed	TAPPI brightness, %
1	None	None	..	..	2.9	59.7	14.9	82 3
2	None	12.5	31	3.9	1.1	74.2	50.4	85 9
3	0.1	12.5	24	3.0	1.6	71.2	45.7	85.6
4	0.25	12.5	7	0.9	3.1	63.2	26.8	83.8
5	1.0	12.5	3	0.4	3.5	61.9[a]	22.3	83.8
6	2.0	12.5	5	0.6	5.3	59.5[a]	23.4	83.6

Twenty-five-pound basis weight (25 × 40—500), bleached sulphite, 2% alum, no size.
Starch was cooked and prepared in 20% water solution.
[a] Results are out of line with per cent titanium dioxide ash, apparently due to experimental error.

Table II indicates that even relatively small amounts of chlorinated starch as 0.1 or 0.25% is sufficient to lower the titanium dioxide retention markedly. Therefore, it is obvious that the paper industry needs some method of retaining the pigment when small amounts of chlorinated starch are present in the beater.

Table III. The Effect of Basis Weight on the Beater Retention of Titanium Dioxide in the Presence of Chlorinated Corn Starch

No.	Chlorinated starch added, %	TiO_2 added, %	Basis weight, lb.	TiO_2 retention, %	TiO_2 ash, %	Bursting strength, p.s.i.
1	None	None	25	..	...	1.5
2	None	None	30	..	...	3.5
3	None	None	40	..	...	8.0
4	None	None	50	..	...	12
5	None	25	25	38	9.6	0.5
6	None	25	30	40	9.9	0.5
7	None	25	40	44	11.0	1.3
8	None	25	50	48	12.0	3.7
9	2.0	25	25	6	1.5	2.1
10	2.0	25	30	10	2.4	3.8
11	2.0	25	40	8	1.9	6.8
12	2.0	25	50	10	2.4	12

Bleached sulphite, 2% alum, 2% rosin size.

Table IV. Effect of Alum Concentration on the Beater Retention of Titanium Dioxide in the Presence of 1% Chlorinated Corn Starch

No.	Alum concentration, %	Chlorinated starch, %	Titanium dioxide retention, %
1	0.1	None	10
2	0.1	1%	6
3	1.0	None	48
4	1.0	1%	5
5	2.0	None	46
6	2.0	1%	10
7	5.0	None	40
8	5.0	1%	12
9	10.0	None	37
10	10.0	1%	10

Thirty-pound basis weight (25 × 40—500), 12½% TiO_2 added, 2% rosin size.

THE EFFECT OF BASIS WEIGHT VARIATION

It is well known that an increase in the basis weight of a sheet will increase the retention of fillers. In Table III the retention is shown both with and without chlorinated starch. The results indicate that an increase in basis weight from 25 to 50 lb. does not cause an appreciable increase in retention when chlorinated starch is present.

THE EFFECT OF ALUM CONCENTRATION

The effect of alum concentration on the improvement of retention is well known, so a ladder of various concentrations was run with and without chlorinated starch.

The results shown in Table IV indicate that there is an optimum amount of alum for the best retention of titanium dioxide in the absence of starch. This has been reported by other investigators on various fillers and by Willets (*3*) on titanium dioxide. The data also show that an increase in the alum concentration to 10% in the presence of 1% chlorinated starch does improve the retention slightly but the amount is far below the no starch level.

THE EFFECT OF PIGMENT PREFLOCCULATION

The normal procedure in the manufacture of handsheets requires the addition of the starch and the pigment to the pulp prior to the alum addition. By this method, the pigment is flocculated by the alum in the presence of the fiber. If the starch is functioning as a protective colloid and reducing the flocculation effect of the alum, it might improve retention to preflocculate the pigment with alum or use a nonwater dispersing type of titanium dioxide.

Table V gives the results of a study testing this procedure. The data show that retention is slightly poorer with this method than with the normal one. Apparently, the chlorinated starch is able to maintain a dispersion of titanium dioxide whether it is added before or after the alum addition. One other possibility that was not investigated was the addition of the flocculated pigment to the pulp, followed by the starch addition.

Table V. The Retention of Preflocculated Titanium Dioxide in the Presence of Chlorinated Corn Starch

No	Pigment	Starch concentration, %	Pigment retention, % — Separately flocculated[a]	Pigment retention, % — Normal flocculation
1	Water dispersing	None	44	46
2	Water dispersing	1	9	10
3	Water dispersing	2	7	7
4	Water dispersing	4	3	4
5	Nonwater dispersing	None	..	40
6	Nonwater dispersing	1	..	14

Thirty-pound basis weight (25 × 40—500), 2% alum, 2% rosin size, 12½% TiO_2 added.

[a] The pigment was first flocculated by alum before addition to the starch treated furnish.

THE EFFECT OF SODIUM ALUMINATE ADDITION

A frequently used (*4*) method of improving the retention of titanium dioxide is the addition of sodium aluminate to the beater in the presence of alum. The method used in Table VI was the addition of pigment to the pulp followed by alum to a pH of 4.5 and then sodium aluminate to a pH of 5.0. The data in Table VI show that the sodium aluminate definitely improves retention of titanium dioxide in nonstarch containing furnishes but loses much of its advantage in the presence of chlorinated starch.

THE EFFECT OF SODIUM PHOSPHO ALUMINATE ADDITION

Sodium phospho aluminate (*5*) is being used in a number of paper mills for improving the retention of fillers in the beater. It is claimed that this chemical is superior to sodium aluminate since a buildup of sodium sulphate in the white water is avoided. Table VII shows a study of titanium dioxide retention in the presence of 2% of this chemical. Our experiments indicate that sodium phospho aluminate does improve the retention markedly in nonstarch-containing furnishes. It also improves the retention in starch-containing furnishes but not sufficiently to match the no starch, no sodium phospho aluminate control.

THE EFFECT OF ANIMAL GLUE ADDITION

The use of specially prepared colloidal animal glue has been mentioned in the literature (*6*, *7*) and is commonly used in the paper industry. Table VIII shows a study of animal glue on the retention of titanium dioxide alone and in the presence of chlorinated starch. These data show that animal glue does improve the re-

Table VI. The Effect of Sodium Aluminate on the Beater Retention of Titanium Dioxide in the Presence of Chlorinated Corn Starch

No.	Sodium aluminate	Chlorinated starch, %	TiO_2 added, %	TiO_2 retention, %	Ash, %	Bursting strength, p.s.i.	TAPPI opacity, % — Unwaxed	TAPPI opacity, % — Waxed	TAPPI brightness, %
1	None	None	None	..	..	3.3	57.0	14.1	83.3
2	None	None	12.5	30	3.8	1.4	72.2	48.5	86.4
3	None	2	12.5	2	0.3	3.8	58.8	19.1	82.7
4	Yes	None	12.5	42	5.2	1.4	74.5	53.6	86.7
5	Yes	2	12.5	5	0.6	5.3	59.8	23.4	83.6

Twenty-five-pound basis weight (25 × 40—500), bleached sulphite, alum added to pH 4.5, sodium aluminate added to pH 5.0.

Table VII. The Effect of Sodium Phospho Aluminate on the Beater Retention of Titanium Dioxide in the Presence of Chlorinated Corn Starch

No.	S.P.A., %	Chlorinated starch, %	TiO_2 added, %	TiO_2 retention, %	Ash, %	Bursting strength, p.s.i.	TAPPI opacity, % Unwaxed	TAPPI opacity, % Waxed	TAPPI brightness, %
1	None	None	None	..	..	3.8	57.4	13.9	82.3
2	None	None	12.5	37	4.6	1.4	72.4	50.0	85.5
3	None	2	12.5	3	0.4	3.9	57.8	18.0	83.2
4	2	None	12.5	50	6.2	1.4	74.6	55.6	86.4
5	2	2	12.5	27	3.4	4.6	70.5	43.8	85.3

Twenty-five-pound basis weight (25 × 40—500), bleached sulphite handsheets, 2% alum, no size.

tention of the pigment noticeably when starch is absent. However, chlorinated starch does tend to nullify the good effect of the glue to a considerable extent. Animal glue improves the retention of the pigment where the starch treated sample is compared with the starch treated control (no. 5 versus no. 3).

THE EFFECT OF IDAHO POTATO STARCH ADDITION

Idaho potato starch has been promoted in recent years as a method of improving filler retention and increasing physical strength. Table IX shows a comparison of this agent alone and in the presence of chlorinated starch. The data show that this agent does improve the titanium dioxide retention slightly over the pigmented control and at the same time markedly improves the bursting strength. Considerable loss in retention occurs when the chlorinated starch is also added to the furnish but the end result is considerably higher than the chlorinated starch control in pigment retention and in bursting strength.

THE EFFECT OF DIATOMACEOUS SILICA ADDITION

Diatomaceous silica has been promoted as a titanium dioxide retention aid and for improving the brightness and opacity of furnishes. The method of addition reported in Table X follows the suppliers' recommendation of equal quantities of silica and titanium dioxide. The data indicate that an improvement in titanium dioxide retention does occur from the use of this filler but most of the advantage is lost when chlorinated starch is present.

THE EFFECTS OF CORN STARCH ADDITION

During the past year, a new type of beater starch described as cationic has been placed on the market. The suppliers claim that this material will increase the bursting strength and improve the filler retention. The results of our tests on this material are shown in Tables XI and XII. They indicate that this material gave the best retention improvement per unit weight of the various additives tested. This retention improvement is not appreciably affected by the presence of chlorinated starch. The data shown in Table XI indicate that this beater additive is effective in amounts as small as 0.1% of the dry pulp.

Table VIII. The Effect of Animal Glue on the Beater Retention of Titanium Dioxide in the Presence of Chlorinated Corn Starch

No.	Animal glue, %	Chlorinated starch, %	TiO_2 added, %	TiO_2 retention, %	Ash, %	Bursting strength, p.s.i.	TAPPI opacity, % Unwaxed	TAPPI opacity, % Waxed	TAPPI brightness, %
1	None	None	None	..	..	2.3	60.6	15.2	83.5
2	None	None	12.5	29	3.6	0.6	73.7	48.1	86.8
3	None	2	12.5	4	0.5	2.4	62.4	21.1	84.4
4	2	None	12.5	35	4.4	1.6	74.7	50.2	86.7
5	2	2	12.5	17	2.1	3.2	67.5	35.1	85.1

Twenty-five-pound basis weight (25 × 40—500), bleached sulphite handsheets, 2% alum.
No size, animal glue treated and aged according to (*6*, *7*).

MATERIALS AND METHOD

The paper pulp used for this study was bleached sulphite secured from a West Coast supplier. The pulp was beaten in a Noble and Wood cycle beater at 4% consistency to a Schopper-Riegler of 32°. Handsheets were made 8 by 8 in. on a Noble & Wood sheet machine at constant basis weight. All basis weights are given on a moisture-free dry basis. Distilled water was used in all tests.

Unless otherwise specified, the order of addition of the various additives was pulp first, followed by the pigment, starch, and then the alum. After thorough agitation in the proportioner, handsheets were made. Sheets were calendered at 100 lb. per lineal in. at 180°F.

The pigment content of the sheets was determined by ashing and weighing, except in the case of the diatomaceous silica study where TAPPI Standard T 439

Table IX. The Effect of Idaho Potato Starch on the Beater Retention of Titanium Dioxide in the Presence of Chlorinated Corn Starch

No.	Idaho potato starch, %	Chlorinated starch, %	TiO_2 added, %	TiO_2 retention, %	Ash, %	Bursting strength, p.s.i.	TAPPI opacity, % Unwaxed	TAPPI opacity, % Waxed	TAPPI brightness, %
1	None	None	None	..	...	4.0	57.9	13.8	82.0
2	None	None	12.5	29	3.60	1.7	71.7	48.2	85.6
3	None	2	12.5	3	0.32	3.8	58.8	19.1	82.7
4	2	None	12.5	32	4.00	6.3	71.5	46.9	85.3
5	2	2	12.5	19	2.4	8.3	64.9	34.9	83.9

Twenty-five-pound basis weight (25 × 40—500), bleached sulphite handsheets, 2% alum, no size.

Table X. The Effect of Diatomaceous Silica on the Beater Retention of Titanium Dioxide in the Presence of Chlorinated Corn Starch

No.	Diatomaceous silica, %	Chlorinated starch, %	TiO_2 added, %	Filler retention, % Total	TiO_2	Silica	Ash, %	Bursting strength, p.s.i.	TAPPI opacity, % Unwaxed	Waxed	TAPPI brightness, %
1	None	None	None	..	...	...	..	3.4	56.7	13.5	83.7
2	None	None	12.5	31	31	None	3.9	1.2	72.0	48.1	86.5
3	None	2	12.5	3	3	None	0.4	3.9	57.8	18.0	83.2
4	12.5	None	None	8	None	8	1.0	2.8	57.8	14.3	83.2
5	12.5	None	12.5	23	36	10	5.8	1.0	73.7	48.8	86.6
6	12.5	2	12.5	5	2	8	1.2	2.5	61.2	19.7	84.2

Twenty-five-pound basis weight (25 × 40—500), bleached sulphite handsheets; 2% alum, no size.

m-44 was used. Pigment retention was calculated from the amount added and the amount retained.

TAPPI Standard methods were followed in determining the bursting strength, waxed and dry opacity. The brightness was determined on a Hunter Multipurpose Reflectometer using standards determined by the General Electric brightness meter.

The sheets were dried and then waxed by immersion in a microcrystalline wax blend (95% microcrystalline wax, 5% polyethylene) at 120°C. All sheets were saturated with wax and the excess removed between heated pressure rolls.

The starches used in this study were secured from the regular paper suppliers and are regular commercial items. All were cooked at 20% solids by heating in water at 180°F. for 5 min. after clarification. Where starches were added without cooking or cooked at different solids, a notation will be found in the table.

Table XI. The Effect of Cationic Starch on the Beater Retention of Titanium Dioxide in the Presence of Chlorinated Corn Starch

No.	TiO_2 added, %	Chlorinated starch, %	Cationic starch, %	TiO_2 retention, %	Ash, %	Bursting strength, p.s.i.	TAPPI opacity, % Unwaxed	Waxed	TAPPI brightness, %
1	None	None	None	..	..	4.0	57.9	13.8	82.0
2	12.5	None	None	29	3.6	1.7	71.7	48.2	85.6
3	12.5	2	None	2	0.3	3.8	58.8	19.1	82.7
4	12.5	None	2	51	6.4	2.8	77.2	56.4	87.5
5	12.5	2	2	48	6.0	4.8	75.4	54.6	86.4

Twenty-five-pound basis weight (25 × 40—500), 2% alum. Cationic starch prepared and added as 2% water solution.

Table XII. The Effect of Varying Cationic Starch Content on the Beater Retention of Titanium Dioxide Pigment

No.	Cationic starch, %	TiO_2 added, %	TiO_2 retention, %	Ash, %	Bursting strength, p.s.i.	TAPPI opacity, % Unwaxed	Waxed	TAPPI brightness, %
1	None	None	..	..	2.9	59.7	14.9	82.3
2	None	12.5	31	3.9	1.1	74.2	50.4	85.9
3	0.1	12.5	45	5.6	1.4	76.5	54.1	86.9
4	0.25	12.5	46	5.8	1.1	76.6	54.4	87.1
5	0.5	12.5	47	5.9	1.5	76.6	53.8	87.1
6	1.0	12.5	53	6.6	1.3	77.2	55.8	87.4
7	1.5	12.5	54	6.7	1.8	77.6	56.8	87.6
8	2.0	12.5	51	6.4	2.8	77.2	56.4	87.5

Twenty-five-pound basis weight (25 × 40—500), 12.5% TiO_2 added, 2% alum. Cationic starch solution made up at 2% and heated to 180°F. for clearing.

SUMMARY AND CONCLUSIONS

The results of the handsheet data given in the previous discussion indicate that:

1. Many forms of beater added corn starch will seriously reduce the beater retention of titanium dioxide if added in the cooked form. Slight reduction occurs if the starches are added dry. This confirms the results of previous investigators.

2. Chlorinated corn starch is one of the worst offenders in reducing the beater retention of the pigment. This starch may be present in the furnish, due to: (a) deliberate addition to maintain or increase the physical strength of the pigmented paper, or (b) an unavoidable but necessary addition from the return of broke from the coating mill or the use of coated waste paper in the furnish.

3. Titanium dioxide retention improvements from the use of basis weight increase, pigment preflocculation, alum, sodium aluminate, animal glue, Idaho potato starch, and diatomaceous silica addition, are greatly reduced by the presence of chlorinated corn starch.

4. Cationic starch and sodium phospho aluminate gave the best pigment retention in the presence of chlorinated corn starch.

It should be noted that the determination of titanium dioxide retention on handsheets of a 25-lb. basis weight is subject to considerable experimental error (estimated average relative error ± 6%). For this reason, conclusions are based solely on differences of large magnitude.

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Properties and Analysis of Inorganic Pulping Solutions

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The physical and chemical properties of a pulping solution are essentially those of the electrolytes constituting the solution. The distribution of the ionic species present in the aqueous medium and its bearing on chemical analysis are discussed with respect to the equilibria involved. Solubility and density information on the common pulping solutions are reviewed and new data are presented. The conventional analysis of pulping solutions is based on two basic chemical techniques: acidimetry and iodometry. The application of these two methods to the most complex system, a recovered neutral sulphite cooking liquor, serves to illustrate their reliability and limitations. The results of chemical analyses can be used to obtain certain specific information concerning the operations of a pulp mill by means of material balances and judicious interpretation. Suggestions are offered for the redefinition of some of the important characteristics of pulping solutions, to extend their range of usefulness and to avoid ambiguity.

CHEMICAL pulping is largely governed by the properties of certain common inorganic compounds in an aqueous solution. The classification into soda, sulphate (kraft), neutral sulphite, and acid sulphite processes is conventional but arbitrary. With the exception of the acid sulphite process, sodium compounds are the general choice and the trend of the industry is toward the use of more sodium-base liquors.

The active pulping compounds are shown in Table I, arranged in the order of decreasing alkalinity or increasing acidity. It is evident that the pulping action is generally the result of a mixture of these compounds in a close neighborhood, or more correctly, a mixture of ionic species. On a further analysis, all the anionic species can be derived from three acids, again in the order of increasing acidity, hydrosulphuric acid (hydrogen sulphide), carbonic acid, and sulphurous acid.

Table I. Sodium-Base Pulping Compounds

pH range	*Compound*	*Pulping process*
13	NaOH	Soda
	Na_2S	
12	Na_2CO_3	Sulphate (kraft)
	NaHS	
9	Na_2SO_3	Neutral sulphite
	$NaHCO_3$	
5	$NaHSO_3$	Acid sulphite
2	H_2SO_3	

The salts of these weak to moderately strong dibasic acids, when present in an aqueous solution, are subject to the well-known phenomenon of hydrolysis, forming their respective ionic species in the interaction with water. Thus, a solution of sodium sulphide consists of Na^+, H^+ cations, OH^-, HS^-, $S^=$ anions, and undissociated hydrogen sulphide and water in various equilibria. The equilibrium distribution of these components is governed by the dissociation constant of the specific acid involved. The ionic product of water is, for all practical purposes, equal to 10^{-14} at 25°C. The dissociation constants of the acids concerned are shown in Table II, compiled from the recent literature.

Table II. Dissociation Constants

Reaction	*Dissociation constant*	*Temp., °C.*	*Source*
$H_2S = H^+ + HS^-$	$K_1 = 8.7 \times 10^{-8}$	20	Kubli (*1*)
$HS^- = H^+ + S^=$	$K_2 = 7.9 \times 10^{-14}$	20	Konopik and Leberl (*2*)
$H_2CO_3 = H^+ + HCO_3^-$	$K_1 = 3.5 \times 10^{-7}$	25	Kauko (*3*)
$HCO_3^- = H^+ + CO_3^=$	$K_2 = 5.7 \times 10^{-11}$	25	Kauko and Mantere (*4*)
$H_2SO_3 = H^+ + HSO_3^-$	$K_1 = 1.3 \times 10^{-2}$	25	Yui (*5*), Johnstone and Leppla (*6*)
$HSO_3^- = H^+ + SO_3^=$	$K_2 = 6.2 \times 10^{-8}$	25	Yui (*5*), Tartar and Garretson (*7*)

At room temperature, in a dilute solution of a hydrolyzed salt, sodium sulphide, for example, the following simple relations apply:

$$K_1 = \frac{C_{H^+} \times C_{HS^-}}{C_{H_2S}} \quad (1)$$

$$K_2 = \frac{C_{H^+} \times C_{S^=}}{C_{HS^-}} \quad (2)$$

$$K_W = C_{H^+} \times C_{OH^-} \quad (3)$$

where K_1 and K_2 are, respectively, the primary and secondary dissociation constants of hydrogen sulphide, K_W that of water, and C the concentration in gram-ions or gram-moles per liter. When such a solution is acidified, the distribution of all the ionic and molecular species, resulting from the hydrolysis of the salt, at a given hydrogen ion concentration of pH can be estimated by the above relations in the following manner:

$$\frac{C_{HS^-}}{C_{H_2S}} = \frac{K_1}{C_{H^+}} = K_1 \times 10^{pH} \quad (4)$$

$$\frac{C_{S^=}}{C_{HS^-}} = \frac{K_2}{C_{H^+}} = K_2 \times 10^{pH} \quad (5)$$

Figure 1 illustrates the ionic distribution for each of the three acids concerned as a function of pH. For example, at a pH value of 9, hydrosulphide ions and undissociated hydrogen sulphide are in equilibrium at a molar concentration ratio of 99 to 1, bicarbonate and carbonate ions at a ratio of 95 to 5, and sulphite and bisulphite ions at a ratio of 98 to 2.

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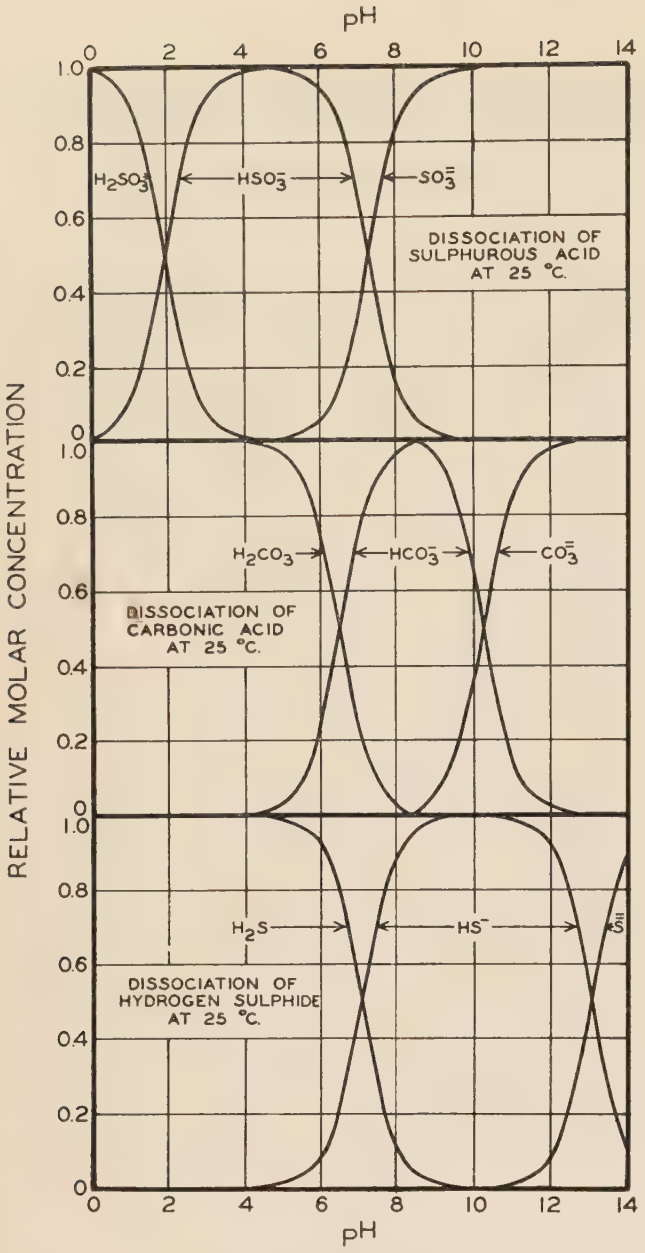

Fig. 1. Ionic distribution

It is evident from the foregoing discussion that in a pulping solution of a mixture of these salts at a certain pH, not all the ionic species are present in appreciable quantities. For a neutral sulphite solution the presence of carbonate or hydrosulphide ions renders the bisulphite ions negligible and vice versa. In an acid sulphite solution, sodium sulphide cannot coexist with free sulphur dioxide in moderate quantities.

The above interpretation of the ionic behavior of the pulping solution is obviously an oversimplification in that it neglects the activity coefficients and their variations with concentration, temperature, and ionic strength. It, nevertheless, serves as a first approximation and as a basis of further study of a complex problem.

In the preparation of pulping solutions, some of the physical properties are of practical importance, among which solubility and density will be considered. The solubilities of the cooking chemicals, with the exceptions of sodium hydrosulphide and sodium bisulphite, are available in the literature, and their individual solubility behavior is illustrated in Fig. 2.

Among the common cooking chemicals, sodium hydroxide is the most soluble and sodium bicarbonate the least. Sodium sulphite has a marked inverse solubility above the transition temperature of 33.5°C. Most of these chemicals also exhibit metastable conditions, the solution being supersaturated with respect to the normal crystal form in question.

The solubilities of a mixture of strong electrolytes are of a more complex nature. Generally speaking, the solubility of an individual compound decreases in the presence of others as a result of the common ion effect. The trend of the industry is to employ cooking liquors of higher and higher concentrations, especially in continuous semichemical digesters. The solubility of the least soluble cooking chemical imposes a practical limit to the overall attainable concentration of the pulping liquor.

The solubility of sulphur dioxide in a sodium bisulphite solution has not been determined, but data on the equilibria of similar systems, SO_2-$Ca(HSO_3)_2$-H_2O (*8*), and SO_2-NH_4HSO_3-H_2O (*9*) are available.

For the design of equipment handling pulping solutions, density data are indispensable. The densities of the aqueous solutions of the cooking chemicals concerned, again with the exceptions of sodium hydrosulphite and sodium bisulphite, have been either cited from the literature or determined experimentally. Figure 3 shows the smoothed data for sodium hydroxide, taken from the

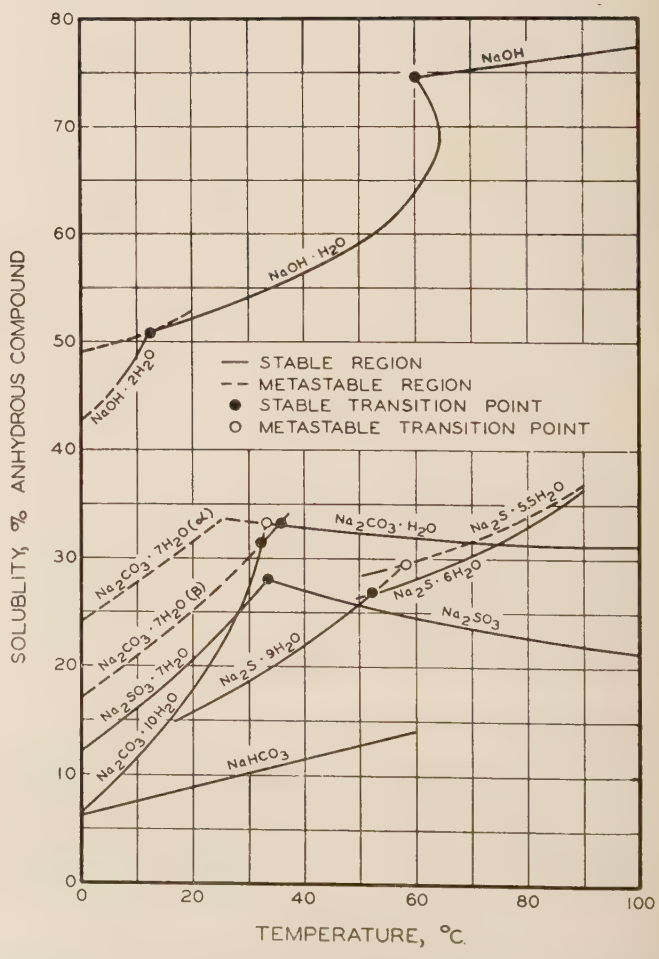

Fig. 2. Solubilities of cooking chemicals in aqueous solutions; data from I.C.T.

International Critical Tables. The data for sodium carbonate (Fig. 4) were partly based on the International Critical Tables in the low concentration range of 1 to 14% and partly on Taylor's work (*10*) in the range of 14 to 21%. The densities of the aqueous solutions of sodium bicarbonate (Fig. 5), sodium sulphide (Fig. 6), and sodium sulphite (Fig. 7) were experimentally measured by the conventional pycnometric method. The agreement of these data with the values cited in the International Critical Tables at one single temperature is well within 1% in all three cases. It is to be noted that the density-concentration isothermals are almost linear, which fact permits interpolation and extrapolation with reasonable accuracy.

The chemical constituents of pulping solutions comprise principally sodium-sulphur compounds in various degrees of alkalinity, as arranged in Table I. For pulping purposes (penetration, delignification, hydrolysis, saponification, etc.), acidity alone is evidently not sufficient to characterize the solutions. The sulphur-bearing anions (HS^-, $S^=$, HSO_3^-, $SO_3^=$) play important roles in pulping action. In addition, there are present some relatively inactive neutral compounds, such as sodium sulphate and sodium thiosulphate.

Table III. Constituents of Pulping Solutions

	Chemical constituents		
	Major	*Intermediate*	*Minor*
Soda	$NaOH$	Na_2CO_3	...
Sulphate (kraft)	$NaOH$, Na_2S ($NaHS$)	Na_2CO_3	Na_2SO_4, (Na_2SO_3, $Na_2S_2O_3$, Na_2S_n)
Neutral sulphite	Na_2SO_3 ($NaHSO_3$)	$NaHCO_3$ (Na_2CO_3), $NaHS$	$Na_2S_2O_3$, Na_2SO_4, (Na_2S_n)
Acid sulphite	H_2SO_3 (SO_2)	$NaHSO_3$	Na_2SO_4

For the sake of convenience in discussion, these constituents are divided, as shown in Table III, into three classes: major, intermediate, and minor, depending on the relative quantities present. The division is arbitrary. In accordance with the concepts generally adopted in the pulping industry, the major constituents are considered as active chemicals, the intermediate constituents buffer chemicals, and the minor constituents impurities and inerts.

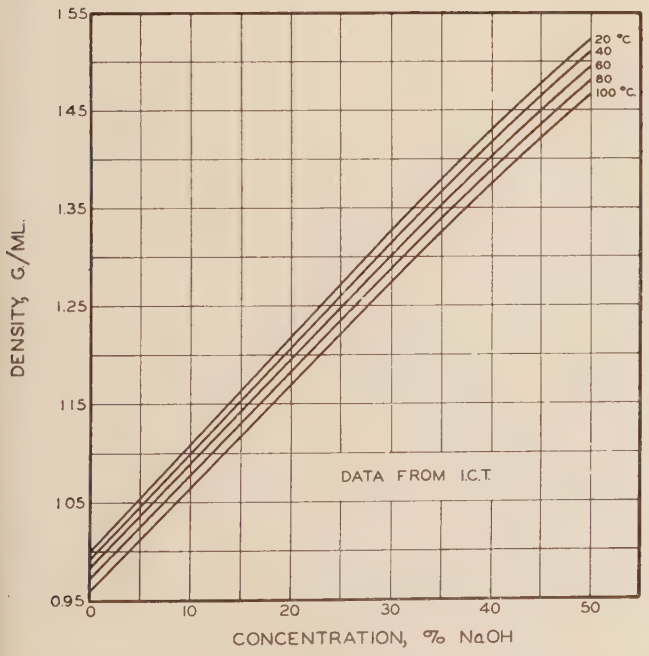

Fig. 3. Density of sodium hydroxide solution

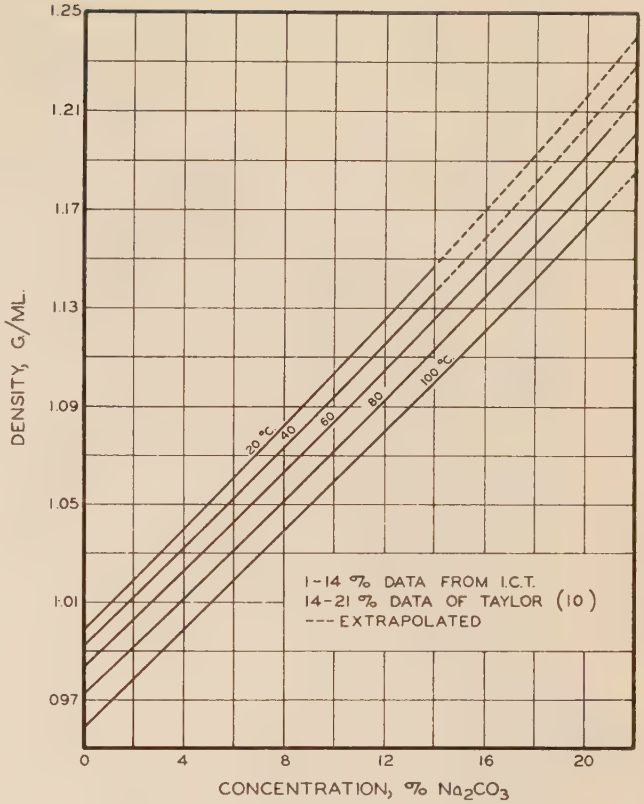

Fig. 4. Density of sodium carbonate solution

The chemical analysis of the pulping solutions is based on two common analytical techniques: acidimetry and iodometry. For a solution of relatively simple composition, such as a soda or acid sulphite cooking liquor, the analyses are well standardized. Even in the case of sulphate (kraft) white liquor, no particular difficulties are involved. For a neutral sulphite cooking liquor, however, several analytical problems arise because of its complexity in composition and the wider pH range encountered.

Taking, as an example, a neutral sulphite liquor recovered from a smelt solution, the major constituents are sodium sulphite, and possibly bisulphite, while various quantities of carbonate, bicarbonate, hydrosulphide, thiosulphate, and sulphate may be present, because of the cooking requirements and as a result of the recovery process. In an extreme case, several forms of polysulphides may also exist. The method of analysis for such a liquor can be adapted from that for kraft white liquor (*11*). The kraft analysis consists essentially of five determinations: total alkali, active alkali, total reducing compounds, sulphide-free reducing compounds, and thiosulphate. The first two fall in the realm of acidimetry, and the remaining three iodometry.

Total Alkali. A sample of the liquor is titrated with standard hydrochloric acid, using methyl orange (pH = 4) as an indicator. The result of the titration is a measure of the total basic compounds and is expressed as T.A. in gram equivalents per liter.

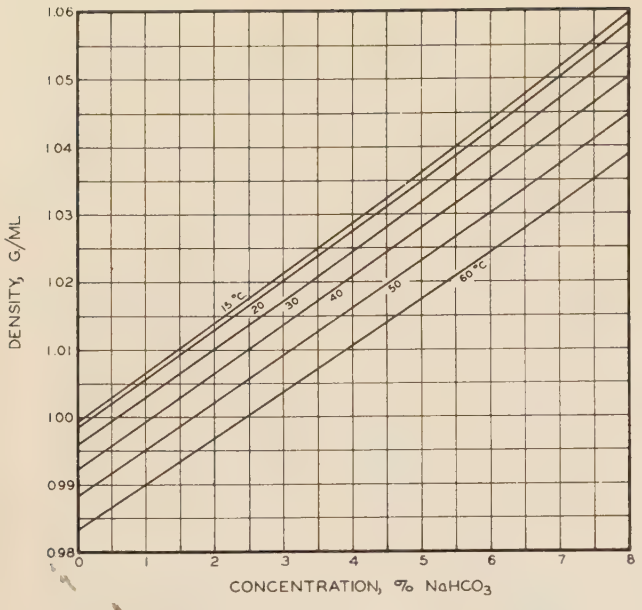

Fig. 5. ***Density of sodium bicarbonate solution***

Active Alkali. A sample of the liquor is diluted and mixed with barium chloride solution in slight excess to precipitate the insoluble barium salts. The supernatant solution is titrated with standard acid, using methyl orange as an indicator. The result is a measure of the basic constituents not precipitated by barium and is denoted by A.A. in gram equivalents per liter.

Total Reducing Compounds. A sample is pipetted into a measured excess of acidified standard iodine solution. The excess iodine which does not react with the sample is determined by the immediate back-titration of this mixture with standard sodium thiosulphate solution. The iodine removed by reaction with the sample is a measure of the total reducing compounds in the sample, and is recorded as T.R.C. in gram equivalents per liter.

Sulphide-Free Reducing Compounds. A portion of the liquor is treated with a slight excess of zinc carbonate suspension to precipitate the insoluble zinc sulphide. The supernatant solution is analyzed iodometrically for the remaining reducing compounds, and the result is expressed as S.F.R.C. in gram equivalents per liter.

Thiosulphate. To a second sample of the sulphide-free solution an excess of formaldehyde is added to form an aldehyde-sulphite compound. By an iodometric titration under an acid condition, the amount of thiosulphate in the sample is determined. The result of the determination is recorded as THIO in gram equivalents per liter.

In the application of the kraft method of analysis to a neutral sulphite liquor, several differences must be observed. First, while the pH of a kraft white liquor generally exceeds 12, that of a neutral sulphite liquor may vary from 7 to 10 which is in a sensitive range of the ionic distribution curves of Fig. 1. Within this range, sulphide ions are practically absent, and only hydrosulphide ions can exist. On the other hand, carbonate and bicarbonate ions can be present above a pH of about 8.5, and sulphite-bisulphite ions below 9. This presents a problem in that no simple reliable methods of analysis are known for the quantitative separation of these ionic pairs in their mutual presence. In experimental analyses of neutral sulphite liquors, the semiquantitative separation of these pairs has been estimated from the ionic distribution curves.

Secondly, in the determination of active alkali and sulphide-free reducing compounds, the effectiveness of separation of the ionic constituents is dependent on the relative solubilities of the compounds resulting from the treatment with the precipitating reagents. In a neutral sulphite liquor the presence of bicarbonate and/or bisulphite complicates the situation. The solubilities of all the compounds involved are summarized in Table IV.

Active alkali is intended for the determination of the sum of the hydroxide and sulphide (hydrosulphide) ions, which are basic constituents not precipitated by barium. Because free hydroxide ions (those not derived from hydrolysis) are generally absent in a neutral sulphite liquor, this determination can be dispensed with. Hydrosulphide ions, if present, can be measured iodometrically.

Sulphide-free reducing compounds, as the term implies, would include all except sulphide and hydrosulphide, which are precipitated by zinc carbonate. However, zinc sulphite is believed to be fairly soluble only in a highly alkaline medium. For a neutral sulphite liquor, a part of the sulphite would also be precipitated because of the relatively low pH. This difficulty can be circumvented by adding sufficient sodium hydroxide to the liquor sample prior to the zinc precipitation. J. B. Lewis (*12*) discussed a similar problem in connection with the analysis of alkaline solutions containing sulphur compounds by precipitation with lead acetate.

A third point is concerned with the relative quantities of the various ions present. In a neutral sulphite

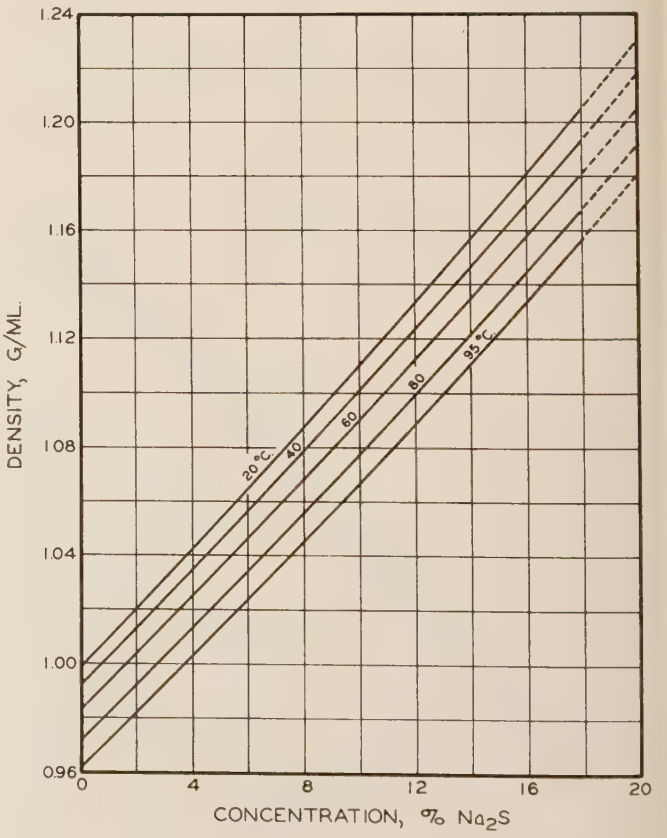

Fig. 6. ***Density of sodium sulphide solution***

Table IV. Solubility Data

Salt	Formula weight	Solubility, g. mole/1000 g. H_2O	Temp., °C.	Source	Note
BaS	169.4	Decomposes	Cold	(*13*)	.....
$Ba(HS)_2$	203.4	2.45	20	(*14*)	Reported as 2.45 g. mole $Ba(HS_2)\cdot 4H_2O$ per 1000 g. H_2O
$Ba(OH)_2$	171.4	2.33×10^{-1}	20	(*14*)	Reported as 0.233 g. mole $Ba(OH)_2\cdot 8H_2O$ per 1000 g. H_2O
$BaCO_3$	197.4	1.4×10^{-2}	18	(*14*)	Reported as 2.7 g. per liter at $P_{CO_2} = 1$ atm.
$Ba(HCO_3)_2$	259.4	2.3×10^{-2}	18	(*14*)	Reported as 5.9 g. per liter at $P_{CO_2} = 25$ atm.
$BaSO_3$	217.4	9.1×10^{-4}	20	(*14*)	.....
$Ba(HSO_3)_2$	299.5	...	..	...	Presumed to be soluble by analogy with $Ca(HSO_3)_2$
BaS_2O_3	249.5	8×10^{-3}	Cold	(*13*)	Reported as 0.2 g. per 100 ml. H_2O
$BaSO_4$	233.4	6.5×10^{-8}	25	(*14*)	.....
ZnS (alpha)	97.4	7.1×10^{-5}	18	(*13*)	Reported as 0.00069 g. per 100 ml. H_2O
$Zn(HS)_2$	131.5	Probably insoluble	Cold	(*15*)	"Probably precipitates as $Zn(HS)_2\cdot 2ZnS$"
$Zn(OH)_2$	99.4	2.6×10^{-8}	18	(*13*)	Reported as 2.6×10^{-7} g. per 100 ml. H_2O
$ZnCO_3$	125.4	8×10^{-5}	15	(*13*)	Reported as 0.001 g. per 100 ml. H_2O
$Zn(HCO_3)_2$	187.4	10.3×10^{-5}	25	(*16*)	Reported as 0.00194 g. per liter at $P_{CO_2} = 4.12$ atm.
$ZnSO_3$	145.5	8.8×10^{-3}	Cold	(*13*)	Reported as 0.16 g. $ZnSO_3\cdot 2H_2O$ (or $ZnSO_3\cdot 2.5H_2O$) per 100 ml. H_2O
$Zn(HSO_3)_2$	227.5	...	..	...	Presumed to be soluble by analogy with $Ca(HSO_3)_2$
ZnS_2O_3	177.5	...	..	...	Presumed to be soluble
$ZnSO_4$	161.4	3.36	20	(*14*)	Reported as 3.36 g. mole $ZnSO_4\cdot 7H_2O$ per 1000 g. H_2O

liquor the chief impurity is usually sodium thiosulphate, which is determined by the formaldehyde method. The formation of a formaldehyde-bisulphite complex is relatively slow. It is important that sufficient time be allowed for the reaction to reach a stable equilibrium before the thiosulphate is titrated. An hour of standing after the introduction of formalin in the presence of ice was found to be adequate.

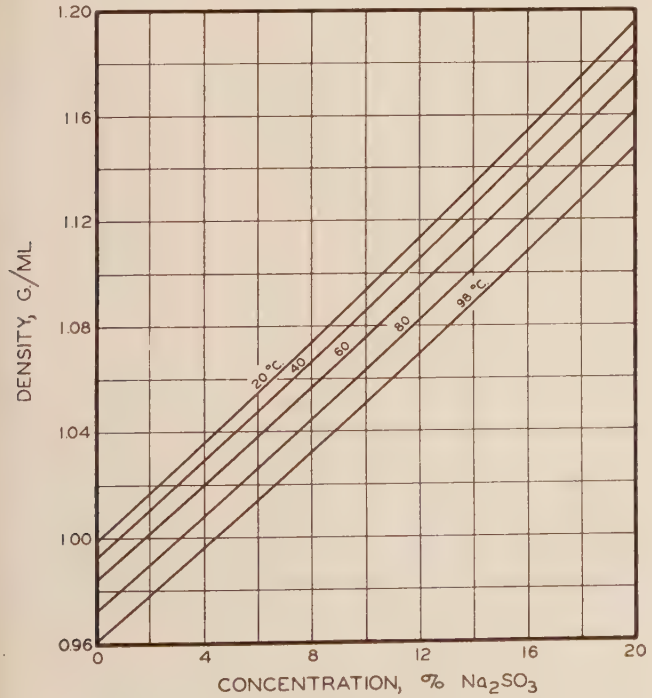

Fig. 7. Density of sodium sulphite solution

Sodium hydrosulphide is present in a neutral sulphite liquor only to a small extent, if at all. Its determination by the difference between the total reducing compounds and the sulphide-free reducing compounds lacks precision. An independent potentiometric determination as silver sulphide (*17, 18, 19*) is recommended.

Table V. Analytical Equivalents

	Acidimetry, neutralization equivalents at methyl orange end point	Iodometry, oxidation-reduction equivalents
$S^=$	$2H^+$	2I
HS^-	H^+	2I
OH^-	H^+	..
H_2S	...	2I
CO_3^-	$2H^+$	..
HCO_3^-	H^+	..
H_2CO_3	...	..
$SO_3^=$	H^+	2I
HSO_3^-	...	2I
H_2SO_3	...	2I
$S_2O_3^=$	...	I
$SO_4^=$	...	..
$S_n^=$	$2H^+$	2I

Sodium sulphate is determined gravimetrically in the conventional manner. Polysulphides (Na_2S_n) may be considered as a group of modified normal sulphides containing extra atoms of loosely-combined sulphur. Analytically, they are determined as normal sulphide with the formation of free sulphur. If they are present in appreciable quantities, a total sulphur determination compared with a sulphur summation of all the known sulphur-bearing compounds, will reveal their presence semiquantitatively.

Table VI. Analysis of Reagents and Synthetic Solution

	Reagent					Synthetic solution (final volume = 250 ml., pH = 9.95 at 25°C.)	
	Sodium sulphite solution	*Sodium thiosulphate solution*	*Sodium sulphide solution*	*Sodium bicarbonate solution*	*Sodium carbonate*		
Amount used	150 ml.	20 ml.	25 ml.	50 ml.	3.0513 g.		
Constituents, millimoles						As mixed, moles	As analyzed, moles
Na_2SO_4	2.625	0.042	0.010	...		0.0027	0.0036
$Na_2S_2O_3$	...	5.264	0.043	...		0.0053	0.0043
Na_2SO_3	76.560	...	0.100	...		0.0757	0.0761
Na_2S	...	...	1.418	...		0.0014	
NaHS	...	...	...	...			0.0004
Na_2CO_3	...	0.118	0.085		28.786	0.0290	0.0223
$NaHCO_3$	...		...	24.950		0.0250	0.0375
Total Na, as calculated from the constituents						0.2532	0.2505
Total S, as calculated from the constituents						0.0898	0.0887
Total C, as calculated from the constituents						0.0540	0.0598

Notes: ...indicates none or negligible amount. A blank space denotes "not analyzed."

Caution must be exercised in the computation of the results from the determinations outlined above. It is necessary to distinguish the neutralizing and reducing equivalents of the various anions present in the sample, as shown in Table V.

The amount of thiosulphate in gram moles per liter is the same as the equivalents per liter determined as THIO from the iodometric titration. One-half of the difference between the sulphide-free reducing compounds and the thiosulphate measures both sulphite and bisulphite in gram moles per liter. The two compounds may be separated in accordance with their ionic distribution (Fig. 1) at the pH of the original liquor.

The amount of hydrosulphide in gram moles per liter is obtained by subtracting the sulphide-free reducing compounds from the total reducing compounds and dividing the difference by two. The total alkali measures, in gram equivalents per liter, the sum of sulphite, hydrosulphide, carbonate, and bicarbonate, but excludes bisulphite and thiosulphate. Since the individual molar quantities of the first two compounds have been calculated, they can be converted to neutralizing equivalents and subtracted from the total alkali. The difference obtained is the combined equivalents of carbonate and bicarbonate, and may be denoted as E. To separate the last two compounds, their normal ionic distribution is again resorted to. The Y-coordinate of Fig. 1 represents the fraction of carbonate (denoted by M) or bicarbonate $(1-M)$ present in the original liquor. Thus, at a known pH of the liquor, we have from analysis

$$2C_{CO_3^=} + C_{HCO_3^-} = E \qquad (1)$$

and from the distribution curve

$$C_{CO_3^=}/C_{HCO_3^-} = M/(1 - M) \qquad (2)$$

where C represents the concentration in gram moles per liter. The equations were easily solved. To summarize the method of calculations from the chemical analyses (T.A., T.R.C., S.F.R.C., and THIO in gram equivalents per liter) and pH of a given liquor, in the absence of sodium bisulphite, we have:

$Na_2S_2O_3$, g. moles/l. = THIO

Na_2SO_3, g. moles/l. = (S.F.R.C. − THIO)/2

NaHS, g. moles/l. = (T.R.C. − S.F.R.C.)/2

$$Na_2CO_3, \text{ g. moles/l.} = \frac{K_2 \times 10^{pH}(2\text{ T.A.} - \text{T.R.C.} + \text{THIO})}{2(2K_2 \times 10^{pH} + 1)}$$

$$NaHCO_3, \text{ g. moles/l.} = \frac{2\text{ T.A.} - \text{T.R.C.} + \text{THIO}}{2(2K_2 \times 10^{pH} + 1)}$$

Na_2SO_4, g. moles/l. from the gravimetric analysis

The modified method of analysis just discussed has been in use in this laboratory for several years. It was tested on several solutions of interest, prepared from individual reagents, and a synthetic solution mixed from known amounts of the individual solutions. The results of the analysis are presented in Table VI.

It is seen that the analytical results of the synthetic solution are in fair agreement with the known values except in the cases of sulphide (hydrosulphide) and carbonate (bicarbonate). By the method of potentiometric determination as silver sulphide, it was found that the solution contained 0.0011 gram mole as Ag_2S, which agreed with 0.0014 gram mole of the original sulphide fairly well. At the measured pH (9.95) of the solution, sulphide ions, however, are precluded in accordance with the previous discussion. The results were therefore recorded as hydrosulphide, which could be derived from the original sulphide by the following reaction:

$$S^= + HCO_3^- = HS^- + CO_3^= \qquad (3)$$

The relative amounts of carbonate and bicarbonate were calculated from the ionic distribution, and the results, therefore, constituted the least reliable part of the analysis.

In the same table are shown the sodium, sulphur, and carbon balances for the synthetic solution. Again the agreement in the carbon balance is not as close as the others because of the oversimplified hypothesis of ionic distribution. It can easily be shown that an arbitrary distribution of carbonate and bicarbonate does not affect the sodium balance, but results in a poor carbon balance. On the other hand, any inaccuracy in the distribution of sulphite and bisulphite or sulphide and hydrosulphide throws off the sodium balance without affecting the sulphur balance.

To characterize a cooking liquor chemically, certain terms are very useful. For the acid sulphite process, the terms, total, combined, and free sulphur dioxide, have been generally adopted. Activity, sulphidity, reduction, and causticity are terms used in the kraft process, although they have never been standardized in their exact meanings. The neutral sulphite liquor has a more complex chemical composition and, therefore, calls for a more extensive characterization. In this paper a set of definitions is suggested to connote the terms to be used in the neutral sulphite process.

1. *Total Chemical* refers to the over-all concentration of all the constituents (major, intermediate, and

Table VII. Cooking Liquor Characterization

	Soda	*Sulphate (kraft)*	*Neutral sulphite*
Total chemical	$NaOH + Na_2CO_3$	$NaOH + Na_2S + Na_2CO_3 + Na_2SO_4$	$Na_2SO_3(NaHSO_3) + Na_2CO_3 + NaHCO_3 + Na_2S_2O_3 + Na_2SO_4$
Activity	$\frac{NaOH}{\text{total chemical}}$	$\frac{NaOH + Na_2S}{\text{total chemical}}$	$\frac{Na_2SO_3(NaHSO_3)}{\text{total chemical}}$
Alkalinity	....	....	$\frac{Na_2CO_3 + NaHCO_3}{Na_2SO_3 + Na_2CO_3 + NaHCO_3}$
Quality	....	....	$\frac{Na_2SO_3(NaHSO_3)}{Na_2SO_3(NaHSO_3) + Na_2S_2O_3}$ For smelt solution
Reduction	....	$\frac{Na_2S}{Na_2S + Na_2SO_4}$	$\frac{Na_2S}{Na_2S + Na_2SO_4}$
Sulphidity	....	$\frac{Na_2S}{Na_2S + Na_2CO_3 + NaOH}$	$\frac{Na_2S}{Na_2S + Na_2CO_3}$
Causticity	Same as activity	$\frac{NaOH}{NaOH + Na_2CO_3}$	....

Note: All constituents to be expressed as Na_2O.

minor) present in a cooking liquor in gram moles per liter, grams per liter or pounds per gallon on a Na_2O basis.

2. *Activity* denotes the percentage of the major constituents in the total chemical, all constituents expressed on a Na_2O basis.

3. *Alkalinity* is expressed by the percentage of carbonate and bicarbonate in the total alkaline constituents on a Na_2O basis.

4. *Quality* is expressed by the percentage of sodium sulphite (and bisulphite, if any) in a mixture of sodium sulphite (bisulphite) and sodium thiosulphate on a Na_2O basis.

5. *Sulphidity* represents the percentage of sodium sulphide in a mixture of sodium sulphide and sodium carbonate (and sodium hydroxide, if any) present in a smelt solution or green liquor on a Na_2O basis.

6. *Reduction* refers to the percentage of sodium sulphide, in a mixture of sodium sulphide and sodium sulphate present in a green liquor or smelt solution on a Na_2O basis.

Some of the above definitions may be applied equally well to the soda and kraft processes, as summarized in Table VII. To characterize a soda liquor, total chemical and activity are sufficient. For a kraft liquor any four of the five characteristics listed in Table VII describe its chemical composition completely. The fifth characteristic is not independent and can be derived from the others. For a numerical example, a kraft white liquor is specified to be of 84% activity, 21.7% sulphidity, 81.5% reduction, and to have a total chemical of 1.172 lb. per gal. The causticity of the liquor can be calculated to be 84.7%.* For an adequate specification of a neutral sulphite liquor, five independent characteristics are required. In addition to the four (total chemical, activity, alkalinity, and quality) listed, the pH of the liquor must be specified in order to separate the carbonate and bicarbonate by their ionic distribution.

Such a method of characterizing a cooking liquor has its advantages. It at once brings to attention the important features of the cooking liquor and its method of preparation or recovery. In a kraft recovery process, for example, reduction serves as an indication of the operating efficiency of the recovery furnace and causticity that of the causticizing system. Sulphidity, used in cooking control, may be simplified to exclude sodium carbonate. In such a case, because only the active chemicals are involved, it may be called active sulphidity.

Based on a simple material balance and some reasonable assumptions, a great deal of information may be derived from the results of a chemical analysis. Given a complete analysis of a neutral sulphite cooking liquor recovered from a smelt solution of known sulphidity, the reduction in the furnace can be deduced from a sodium balance and the assumption that all the sodium sulphate present in the cooking liquor originates in the furnace.

* It will be noted that these definitions, as applied to kraft liquor, are not entirely consistent with the latest revision in TAPPI Standards (O 400 p-54). They have the advantage, however, of consistency with the developing nomenclature for neutral sulphite liquors.

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B.O.D. from Oxygen-Consumed Determinations

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During the course of both laboratory and pilot plant investigations on the treatment of kraft mill effluents considerable comparative data were accumulated by National Council for Stream Improvement engineers on B.O.D. and oxygen-consumed (from permanganate) values. This report is a statistical analysis made for the purpose of determining to what degree the quick oxygen consumed (O.C.) test can be substituted for the lengthy B.O.D. test in determining the oxygen demand of kraft mill effluents.

It has been shown by many investigators (*1, 2, 8, 10*) that chemical oxygen-consumed tests do not present a true picture of the pollutional strength of domestic and industrial wastes. Despite these demonstrations, the necessity for prompt control of industrial waste effluent quality has resulted in numerous studies (*2, 3, 5, 8–11*) to determine an adequate correlation of oxygen-consumed values with the 5-day B.O.D.

Recently, Moore and co-workers (*8, 9*) have developed a silver-catalyzed dichromate method, the results of which show rather good agreement with standard B.O.D. results. Since the Moore method requires 2 hr. refluxing, and the use of apparatus not always available in control laboratories, many workers continue to use the older acid permanganate method.

Schmidt (*2*) has submitted a strong argument against the measurement of oxygen demand in sulphite spent liquor by permanganate consumption. He points out that the conditions of the O.C. test are very different from those in the receiving stream. Schmidt further shows that the analyses of spent sulphite liquors vary greatly and that each constituent consumes entirely different amounts of potassium permanganate, which in no way parallel the B.O.D. of each constituent.

Cameron (*1*) indicates that, although the oxygen consumed from permanganate does not bear any essential relationship to biochemical needs, it is a good relative test.

These known limitations of chemical tests for oxygen consumption ordinarily prevent the substitution of such tests for the 5-day B.O.D. in pollution control work. In the case of a particular effluent from a given mill, however, a chemical test may, after a statistical comparison with the B.O.D., be used as a yardstick to indicate spills of strong liquor or other abnormal or undesirable conditions. Such an approach was made by Chesley, White, and Hogg (*3*) and by the author of this study. The results obtained herein are compared with those of Chesley and co-workers (*3*), and similarities and differences are discussed.

The wastes under investigation were those discharged from a kraft pulp and paper mill and differed from those studied by Chesley, *et al.* (*3*) in that no bleaching or hardwood distillation was performed at this mill and a portion of this total mill effluent was discharged to a pilot-scale accelerated aeration plant. Four-hour composite samples of treatment plant effluent were analyzed and compared with the results of analyses of similar composite samples of total mill waste entering the plant. A comparison of the B.O.D. of the waste after aeration with the B.O.D. of the raw waste provides a measure of treatment plant efficiency.

Biochemical oxygen demand was determined by the azide modification of the Winkler method (*6*) and oxygen consumed was determined by a modification of the standard method (*6*) using acidified 0.125 N potassium permanganate and 0.125 N sodium oxalate. These more concentrated reagents are recommended for strong sewages and industrial wastes by Hoover (*5*) and by the American Public Health Association (*6*).

TOTAL MILL EFFLUENT

The B.O.D. for each sample of mill waste was determined from an average of three replicates at three different dilutions and the O.C. similarly found from the average of duplicate determinations. The results of analyses for 99 separate composite samples of total mill effluent, and the ratio of O.C. to B.O.D. in each case, are given in Table I.

The methods of statistical analysis used to determine the relationship of B.O.D. to O.C. in the total mill effluent and in the pilot plant effluent are described by Dixon and Massey (*7*).

The data of Table I are plotted in a "scatter diagram" (Fig. 1) and a regression line has been drawn. This regression line, representing the best straight-line relationship between the two variables, O.C. and B.O.D., was determined by the method of least squares as shown below.

Let

X = O.C. in parts per million
Y = B.O.D. in parts per million
N = number of observations = 99
$\bar{X}$ = mean value of X = 453.7
$\bar{Y}$ = mean value of Y = 293.8

then $\bar{Y}_x$ = the estimate of the mean Y when X is given, and

$$\bar{Y}_x = \bar{Y} + b(X - \bar{X}) \qquad (1)$$

where

$$b = \frac{\Sigma XY - (\Sigma X \Sigma Y/N)}{\Sigma X^2 - (\Sigma X)^2/N} \qquad (2)$$

$\bar{Y}$ and b are parameters, called regression coefficients. If, in equation (2), the ratio of the terms, $\Sigma X \Sigma Y/N$ to $(\Sigma X)^2/N$, does not differ greatly from 1.0, these terms may be dropped and equation (2) simplified to:

$$b = \frac{\Sigma XY}{\Sigma X^2} \qquad (3)$$

This, in turn, would reduce the regression equation to the form:

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$$y = mx \tag{4}$$

instead of:

$$y = mx + c \tag{5}$$

Calculation of the regression equation resulted in:

$$\bar{Y}_x = 293.8 + 0.596(X - 453.7) \tag{6}$$

or

$$\bar{Y}_x = 0.596X + 23.4 \tag{7}$$

The value of the c term, 23.4 is low compared to $\bar{X}$, 293.8, in equation (7). The possibility of simplifying the equation to the form of equation (4) was therefore suggested. The ratio of the "correction terms" of the numerator and denominator of equation (2) was 0.65, which was considered close enough to 1.0 to justify the use of equation (4). The term, b, was then calculated by equation (3) to be 0.643 and the simplified regression equation became:

$$\bar{Y}_x = 0.643X \tag{8}$$

Table I. Comparison of Oxygen Consumed from Acidified 0.125 *N* $KMnO_4$ with 5-Day B.O.D.—Total Mill Effluent

X, O.C., p.p.m.	*Y*, B.O.D., p.p.m.	*X/Y*, O.C./ B.O.D.	*X*, O.C., p.p.m.	*Y*, B.O.D., p.p.m.	*X/Y*, ratio, O.C./ B.O.D.
148	72	2.06	380	224	1.70
180	131	1.37	360	229	1.57
705	543	1.30	320	244	1.31
768	573	1.34	300	184	1.63
745	463	1.61	280	214	1.31
800	405	1.97	260	249	1.04
480	475	1 01	350	225	1.55
560	293	1.91	350	234	1.50
460	292	1.58	370	240	1.54
520	337	1.54	370	268	1.38
840	512	1.64	380	294	1.29
520	377	1.38	390	272	1.43
840	442	1.90	420	264	1.59
400	207	1.93	400	268	1.49
600	392	1.53	295	163	1.81
430	402	1.07	320	195	1.64
460	447	1.03	480	308	1.56
165	119	1.39	470	274	1.72
180	141	1.28	470	275	1.71
250	204	1.23	380	315	1.21
275	223	1.23	245	163	1.50
410	292	1.40	430	297	1.45
660	330	2.00	550	409	1.35
300	202	1.48	460	281	1.64
390	256	1.52	340	230	1.48
360	283	1.27	580	336	1.73
350	256	1.37	460	286	1.61
430	268	1.60	640	366	1.75
620	439	1.41	580	401	1.45
460	350	1.32	460	263	1.75
610	445	1.37	580	323	1.80
680	329	2.07	530	341	1.56
550	340	1.62	400	224	1.78
500	417	1.20	370	209	1.77
610	479	1.28	390	228	1.71
680	352	1.93	400	228	1.75
520	313	1.66	340	228	1.49
720	406	1.77	380	232	1.64
550	391	1.41	410	250	1.64
580	360	1.61	360	277	1.30
690	357	1.93	325	192	1.69
670	387	1.73	465	232	2.00
340	172	1.97	400	224	1.78
390	220	1.77	350	220	1.59
420	405	1.04	340	208	1.63
630	505	1.25	340	191	1.78
220	172	1.28	300	216	1.39
235	177	1.33	700	398	1.76
420	267	1.57	340	226	1.50
420	252	1.67			

$\bar{X}$ = 453.65. $\bar{Y}$ = 293.84. $\overline{X/Y}$ = 1.55.

The third column of Table I gives a direct ratio of O.C. to B.O.D. the mean of which is 1.55. This ratio, expressed algebraically, is:

$$Y = \frac{X}{1.55} \tag{9}$$

or

$$Y = 0.645X \tag{10}$$

The very near equality of equation (10) to equation (8) and the observed close proximity of the plot of

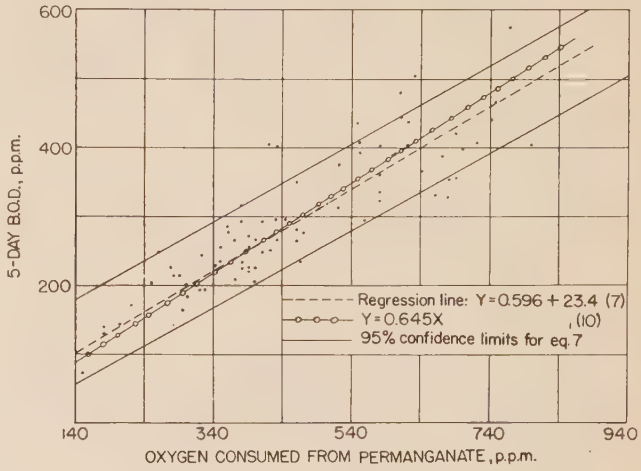

Fig. 1. Regression of O.C. on B.O.D.—total mill wastes

equation (10) to the plot of equation (7) in Fig. 1 indicate that the simplified relationship of B.O.D. to O.C. may be used in this case.

From the data given in Table I, the standard error of estimate for equation (7) has been calculated to be 37.3. The 95% confidence limits for this equation, equal to plus or minus twice the standard error of estimate, are shown in Fig. 1, and may also be considered the 95% confidence limits for equation (10).

The interpretation of this confidence interval may be stated as: 95% of the time any sample with a given *average* O.C. will exhibit a B.O.D. which may be read from Fig. 1 between the confidence limits at the aforementioned O.C. For example, if a sample of total effluent from this kraft mill has an average permanganate oxygen consumed value of 490 p.p.m., then, the probability is 19 in 20 that the B.O.D. of this sample will be between 250 and 377 p.p.m. It must be kept in mind that an *individual* sample may be outside these limits, but replicate determinations, care in sampling, and in analysis will tend to offset wide variations and make these confidence limits valid.

A correlation coefficient, r, may be derived from the regression coefficient, b (*4*). The correlation coefficient contains no additional information, but is useful since it provides in a single figure, a convenient description of the relationship between the two variables.

$$r = \frac{\Sigma XY - (\Sigma X)(\Sigma Y)/N}{\sqrt{\{\Sigma X^2 - [(\Sigma X)^2/N]\}\{\Sigma Y^2 - [(\Sigma Y)^2/N]\}}} \tag{11}$$

An r value of $+1$ denotes perfect functional relationship between Y and X, an increasing X being associated with an increasing Y. Similarly, when $r = -1$,

a negative correlation is indicated; an increasing X is associated with a decreasing Y. When $r = 0$, X and Y are not correlated. Intermediate, fractional values of the correlation coefficient indicate trends, the significance of which may be ascertained from tables found in statistics texts or handbooks (*4, 7*). A highly significant value of r, equal to 0.855, has been calculated for the O.C.-B.O.D. relationship in the kraft mill effluent herein reported.

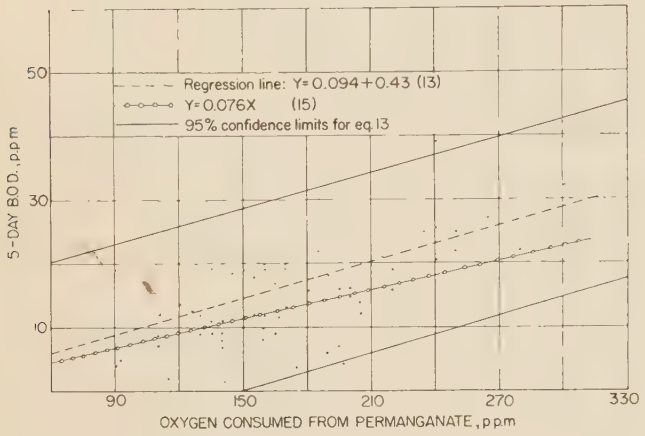

Fig. 2. Regression of O.C. on B.O.D.—oxidized effluent

The B.O.D. to O.C. correlation determined by Chesley and his co-workers (*3*) is given by the equation:

$$Y = 0.516X + 55 \qquad (12)$$

The difference between equations (12) and (7) may be due to dissimilarities in content of the two wastes or to the differences in concentration of the reagents used in these separate investigations. Chesley *et al.* (*3*) used 0.0125 N $KMnO_4$ whereas, in this study, the permanganate was 0.125 N.

It may be concluded, on the basis of this portion of the study, that a definite relationship exists between the permanganate oxygen consumed and the biochemical oxygen demand in the case of this kraft mill effluent.

It should be emphasized that this B.O.D. to O.C. correlation applies to a specific waste and that chemical oxygen consumed values cannot be extrapolated to stream studies. Reasons for this particular limitation will be more clearly shown in the discussion of the oxidized effluent.

If a similar, workable B.O.D. to O.C. correlation could be obtained in the case of a treatment plant effluent, the plant efficiency might be determined and known during the period of operation, rather than 5 days following the test. Then, any adjustments necessary to improve plant operation could be made at once.

TREATED EFFLUENT

The purpose of most sewage and industrial waste treatment plants is to oxidize the biologically-available organic matter contained in the wastes before discharge into the receiving stream, where such an oxidation would tend to deplete the dissolved oxygen of the stream.

A portion of the mill effluent described above was subjected to biochemical oxidation in an aeration plant where the waste under treatment was kept in contact with a biologically active sludge for from 4 to 8 hr. The oxidized effluent was separated from the sludge by sedimentation.

The results of analyses of oxidized effluent are given in Table II. The B.O.D. values are averages of triplicate determinations in each case, and the figures for oxygen-consumed represent averages of duplicate determinations. An O.C./B.O.D. ratio has been calculated for each of the 96 samples of treatment plant effluent and listed in column 3 of Table II.

These data are analyzed statistically by methods similar to those followed for the total mill waste. The regression equation, calculated by the method of least squares, is:

$$\bar{Y}_x = 16.50 + 0.094(X - 171.0) \qquad (13)$$

or

$$\bar{Y}_x = 0.094x + 0.43 \qquad (14)$$

and is plotted in the scatter diagram (Fig. 2).

Table II. Comparison of Oxygen Consumed from 0.125 N $KMnO_4$ with 5-Day B.O.D.—Treated Effluent

X, O.C., p.p.m.	Y, B.O.D., p.p.m.	X/Y, ratio, O.C./B.O.D.	X, O.C., p.p.m.	Y, B.O.D., p.p.m.	X/Y, ratio, O.C./B.O.D.
120	34	3.53	210	16	13.1
78	36	2.16	210	17	12.3
165	38	4.34	200	15	13.3
195	7	27.9	220	19	11.6
230	24	9.58	250	22	11.4
210	16	13.1	250	25	10.0
265	27	9.82	110	13	8.47
155	20	7.74	100	14	7.14
190	18	10.6	100	17	5.88
215	21	10.2	90	19	4.74
170	20	8.50	110	16	6.87
170	24	7.08	130	12	10.8
160	12	13.3	110	9	12.2
195	16	12.2	130	9	14.5
165	17	9.70	110	7	15.7
150	19	7.89	110	5	22.0
155	12	12.9	100	4	25.0
130	12	10.8	140	6	23.3
90	4	22.5	165	9	18.3
105	13	8.08	125	5	25.0
80	4	20.0	115	8	14.4
205	12	17.1	140	11	12.7
150	17	8.82	140	7	20.0
130	9	14.5	160	7	22.9
100	4	25.0	140	8	17.5
105	2	52.5	180	13	13.8
115	4	28.9	140	9	15.6
170	10	17.0	170	13	13.1
210	19	11.0	175	4	43.8
220	16	13.8	190	6	31.7
235	25	9.40	160	8	20.0
200	16	12.5	160	23	6.95
205	25	8.20	160	19	8.41
320	37	8.65	170	19	8.94
315	28	11.3	160	20	8.00
290	26	11.2	200	25	8.00
280	22	12.7	180	18	10.0
285	23	12.4	190	18	10.6
205	14	14.7	190	20	9.50
240	31	7.73	135	10	13.5
205	20	10.3	135	11	12.3
210	17	12.3	135	9	15.0
155	18	8.61	135	9	15.0
180	28	6.43	245	47	5.22
185	22	8.40	200	27	7.41
175	20	8.75	110	12	9.16
180	16	11.2	135	19	7.10
210	17	12.3	220	33	6.66

$\overline{X} = 170.97$. $\overline{Y} = 16.50$. $\overline{X/Y} = 13.2$.

The mean value of the direct ratio of O.C. to B.O.D. for the bio-aeration effluent, as given in Table II is:

$$Y = \frac{X}{13.2} \qquad (15)$$

or

$$Y = 0.076X \qquad (16)$$

and is plotted in Fig. 2.

The ratio of the "correction terms" of equation (2) was found, in the case of this effluent, to be 0.097, and was not considered close enough to 1.0 to warrant the use of the simplified form of the regression equation. The obvious divergence of the plot of equation (16) from that of equation (14) may be another indication that the added term of the regression equation is necessary for a reliable interpretation of oxygen-consumed data for this oxidized effluent. The 95% confidence interval for equation (14) is shown in Fig. 2.

Variance of data greater in the data from this treated effluent than for the total mill waste is indicated by a correlation coefficient calculated to be 0.565. Although still highly significant, this r value suggests that less confidence be placed in this O.C./B.O.D. correlation than in that found in the case of the mill discharge, where r was equal to 0.855.

DISCUSSION

The efficiency of the pilot plant, measured by B.O.D. removal, averaged about 95%. By comparison, the efficiency, measured by reduction in O.C., was only 65%. This discrepancy may be readily understood if it is remembered that B.O.D. measures only organic matter available as food for the aerobic microorganisms found in a stream, while permanganate O.C. is a measure of almost all organic matter present in a pulp mill waste. An inspection of Fig. 3 may clarify this concept.

The organic portion of waste waters from a kraft mill contains, essentially: (1) degradation products of cellulose (hemicelluloses, wood sugars, alcohols, organic acids, etc.); (2) lignin and lignin derivatives. In Fig. 3, the schematic diagram of the total mill waste shows that almost all the organic matter present is oxidized in the O.C. test, but only the biologically available materials are oxidized by the aerobic organisms of the B.O.D. test.

The organic matter of the final effluent after aeration is shown in Fig. 3 to be 95% smaller in area in the A portion only. Lignins and related substances are known

Table III. Removal of Organic Matter by Biological Treatment

ΔX	ΔY	$\Delta X/\Delta Y$	ΔX	ΔY	$\Delta X/\Delta Y$
240	201	1.19	120	229	0.52
210	190	1.11	80	165	0.48
220	209	1.05	30	192	0.16
240	208	1.15	10	224	0.04
140	203	0.69	240	212	1.13
200	214	0.93	250	220	1.14
220	232	0.95	270	223	1.21
170	257	0.66	280	249	1.12
240	251	0.96	270	278	0.97
210	235	0.89	260	260	1.00
170	208	0.82	310	255	1.22
150	212	0.71	270	259	1.04

$\overline{\Delta X}$ = 200.0. $\overline{\Delta Y}$ = 224.4. $\overline{\Delta X/\Delta Y}$ = 0.880.
ΔX = (influent oxygen consumed — effluent O.C.), p.p.m. ΔY = (influent B.O.D. — effluent B.O.D.), p.p.m.

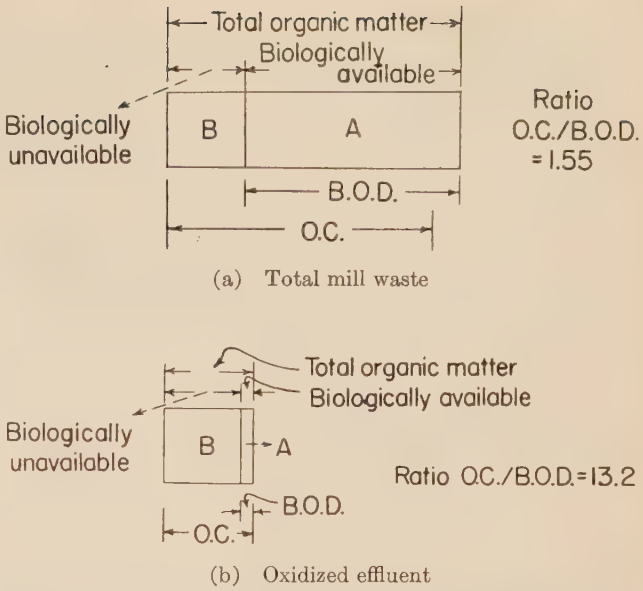

Fig. 3. Schematic representation of organic matter present in kraft mill effluents

to be resistant to microbiological action, hence the reduction in organic matter during treatment must occur in the biologically available portion A. Since treatment removes 95% of A, the ratio of O.C. to B.O.D. (B/A in Fig. 3b) for the treated effluent is expected to be larger than the same ratio for the total mill waste (Fig. 3a).

The biochemical oxidation of organic matter in a stream, treatment plant, or B.O.D. bottle is a function of time. As oxidation of the available organic matter progresses, the biochemically stable materials increase percentage-wise, causing the O.C./B.O.D. ratio to increase. Because of this continuous change in the character of organic matter in a stream, permanganate O.C. values, useful for mill effluents, cannot be used to advantage in determining receiving-water quality.

Following similar lines of reasoning, it may be concluded that a chemical test, such as the permanganate O.C., is of doubtful value in assaying the quality of an effluent from a biological treatment unit. It has been found that the O.C./B.O.D. ratio in a stream increases as one progresses downstream from a source of pollution (*8*). Since a biological treatment plant is essentially an accelerated self-purifying stream, the ratio of O.C./B.O.D. will tend to increase in a similar manner as plant efficiency increases.

An examination of the data of Table II reveals that increased effluent stability, as measured by decreased B.O.D., does result in a higher O.C./B.O.D. ratio. In 26 out of 27 instances where the pilot-plant effluent had a B.O.D. of 10 p.p.m. or below, the O.C./B.O.D. ratio exceeded the mean ratio of 13.2. In 15 out of these 27 cases, the ratio was greater than 150% of the mean.

In a further attempt to predict B.O.D. removal in terms of permanganate oxygen consumed, analyses of 24 separate samples were made before and after treatment. For each sample, effluent O.C. was compared with influent O.C. and effluent B.O.D. with influent B.O.D. These differences are designated as ΔO.C. and ΔB.O.D. and are given in Table III. The re-

gression line for these data is not plotted since the correlation coefficient has been calculated to equal 0.527, which is lower than the r value for the treated effluent, 0.565. An O.C.-B.O.D. regression line for organic matter removed would therefore be viewed with even less confidence than that for the oxidized effluent.

Although permanganate O.C. may indicate roughly the order of magnitude of the B.O.D. of a biological treatment plant effluent, the test cannot be used with confidence to determine B.O.D. removal efficiency of such a unit.

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Correlation of Dye Adsorption and Cupriethylene Viscosity Tests for Pulp Characterization

EDWARD F. THODE and JOHN F. GORHAM

Sulphite cellulose from diverse sources has been given a series of evaluating tests, including dye adsorption, cupriethylenediamine disperse viscosity and strength of handsheets. A statistical analysis of the data shows that the bursting strength of unbeaten pulp handsheets, for example, is principally a function of but two variables—the specific dye adsorption and the cupriethylene viscosity of the pulp. Although there is some scatter of the data, thought to be caused by variation in the chemical composition of the surface of the fibers, the indications of this work are that, irrespective of source, bursting strength is largely determined by the degree of polymerization of the cellulose and the external specific surface of the fibers.

Research into the fundamental properties of wood pulp has often emphasized the discovery of points that would help make "better" paper—that is, stronger and longer lasting—and, at the same time, make it with less expenditure of materials and labor and with a smaller capital investment. Needless to say, the two aims have been found to be antithetical on many occasions. A confusion of aims thus occasionally results, accompanied by difficulty of interpretation on the part of the reader.

In this investigation there was but a single objective: the authors wanted to find out what makes the difference in strength from one sulphite pulp to another. All other considerations have been ignored.

Even when one concentrates on but a single topic, such as strength, one may become confused by seemingly contradictory statements in the literature. In order to establish a common ground for the discussion that follows, the authors would like to summarize their understanding of the causes of pulp strength.

There are probably but two elemental phenomena involved in the production of pulp strength, viz.: adhesion between adjacent fibers and cohesion of the portions of one fiber for themselves. It may be safely argued that *cohesion* is principally a function of: (1) the average molecular weight of the cellulose, (2) the distribution of molecular weight, (3) the crystallinity of the fiber, and (4) the state of swelling of the fiber (principally determined by the moisture content at time of test). *Adhesion* between fibers depends on: (1) the external specific surface of the fibers (i.e., that part of the total fiber surface available for bonding), (2) the chemical composition of the surface, (3) the length and the degree of "curl" of fibers and fibrils, (4) the polarity and surface tension of the liquid from which the sheets are made, and (5) the state of swelling of the fiber at the time of test.

DESIGN OF THE EXPERIMENT

According to the theory of multifactor experiments, one should examine all factors known to affect the desired quality—in this case, pulp strength—at different levels if one is to determine the relative importance of these factors. That is, a number of tests must be conducted, over the course of which all important variables must be changed independently over their entire range, and in several steps. Even though modern methods can show how to minimize the number of tests by changing several variables at once, it would seem an almost hopeless task to perform all the tests required to evaluate all the variables known to affect pulp strength.

Fortunately, some of the factors cited in the preceding section are seldom varied in practice and thus may be held constant throughout the experiment. The de-

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gree of swelling of the fibers at the time of test and the water used in preparation of the handsheets are two such variables.

The two items of crystallinity and of chemical composition of the fiber surface were assumed to be constant throughout the experiment, since tests were limited to sulphite pulps from coniferous wood species. Curl was uncontrolled but assumed not to vary, while the factor of fiber length was assumed to be indistinguishable from the general surface area effect.

Thus in the design of the experiment here reported, all but three of the variables affecting pulp strength were held constant, or, with good reason, assumed to be constant. The problem thus became a matter of determining the relative effects of external specific surface, molecular weight, and molecular weight distribution on pulp strength. Although there was no good reason for assuming uniformity of molecular weight distribution, it was expedient to consider this factor also constant in order to proceed with the examination of the two considered the most important.

The final design of the experiment reduced to a comparison of the strength properties of various sulphite pulps with different average molecular weights and different external surface areas. In order that the effects of uncontrolled variables might be observed, if present, the pulp samples were selected from different

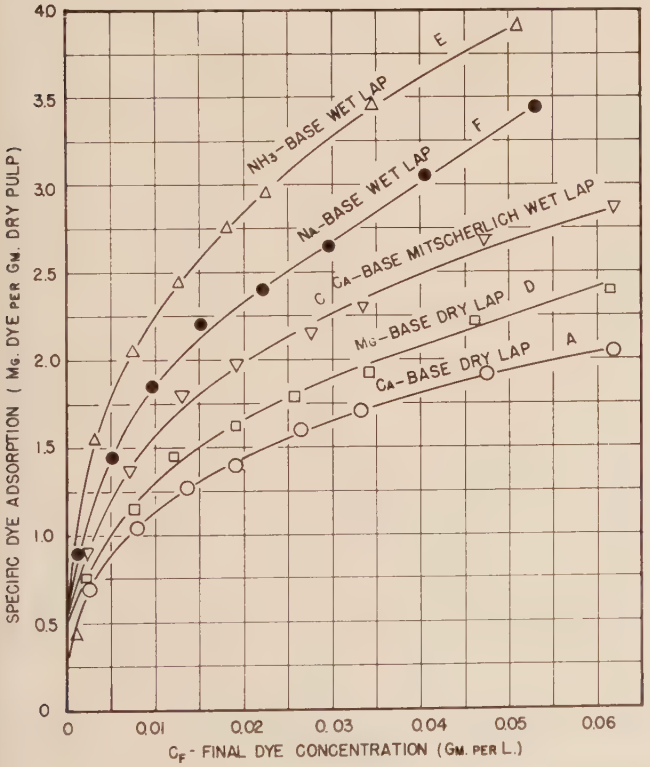

Fig. 1. Adsorption isotherm of Benzo Fast Scarlet 4BSA on various unbeaten sulphite pulps

geographical locations and different sulphite pulping processes.

EXPERIMENTAL PROCEDURE

Samples of ordinary papermaking grades of bleached sulphite pulp were obtained from various commercial sources in the United States. Some samples were machine dried; most were in the form of wet lap containing about 40% solids. Immediately upon receipt, all samples were slurried in distilled water to which 0.5% of formalin (based on dry weight of pulp) had been added. Before any subsequent experiments, this preservative was removed by washing with distilled water.

Small, representative samples of each pulp in the unbeaten state were disintegrated in a Waring Blendor for 2 min. at about 2% consistency, made into handsheets with distilled water and air dried according to TAPPI Standard T 205 m-47 (*5*). These handsheets were sent to the laboratories of the West Virginia Pulp & Paper Co. where cupriethylenediamine disperse viscosity evaluations were performed in accordance with TAPPI Standard T 230 sm-50 (*5*).

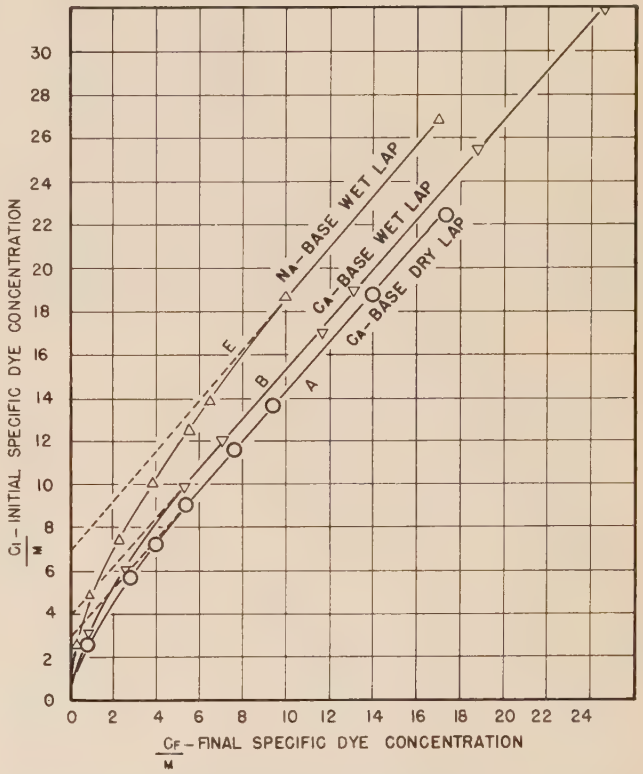

Fig. 2. Initial specific dye concentration versus final specific dye concentration of various unbeaten sulphite pulps

The remaining pulp was then divided and a portion of each sample beaten for 30 min. in a ball mill in accordance with TAPPI Standard T 224 sm-45 (*5*). Beaten and unbeaten samples of each material were then prepared for physical testing (TAPPI Standard T 205 m-53) and tested according to TAPPI Standard T 220 m-47 (*5*). Alpha-cellulose determinations (TAPPI Standard T 203 m-44 (*5*)) were made on unbeaten samples only. Samples of both beaten and unbeaten pulp were used for the obtaining of an adsorption isotherm with the dyestuff Benzo Fast Scarlet 4BSA, using an experimental technique developed in previous papers by one of these authors (*1, 6, 7*). For interpretation of results, however, the data were treated in a manner different from that reported previously.

METHOD OF REPORTING DYE ADSORPTION RESULTS

In previous papers from this laboratory, the adsorp-

Table I. Results of Tests on Various Sulphite Pulps

Pulp sample		x/m × 10^{3}[a]	Burst factor	CED viscosity, cp.	Alpha-cellulose, %	Breaking length, m.	Tear factor	Folding endurance
A. Calcium-base dry lap	Unbeaten	1.12	22.8	100.8	88.3	4,410	117	12
	Beaten	1.76	39.8	...	...	6,250	94.7	114
B. Calcium-base wet lap	Unbeaten	1.56	34.4	186.7	88.3	5,670	88.4	62
	Beaten	2.80	57.4	...	...	8,590	67.8	935
C. Calcium-base Mitscherlich wet lap	Unbeaten	1.12	52.1	187.9	86.4	8,670	94.8	269
	Beaten	2.48	60.8	...	...	9,790	66.5	506
D. Magnesium-base dry lap	Unbeaten	1.32	13.8	110.8	88.4	3,120	133	5
	Beaten	2.48	29.2	...	...	4,720	116	42
E. Ammonia-base wet lap	Unbeaten	2.68	52.9	120.4	87.2	7,960	90.2	346
	Beaten	2.48	60.3	...	...	8,560	80.0	909
F. Sodium-base wet lap	Unbeaten	2.00	58.0	245.5	86.4	9,100	57.0	457
	Beaten	2.48	66.7	...	...	10,130	87.0	1206

[a] Value obtained by extrapolating to $c_f/m = 0$.

tion isotherms of the various pulps studied have been compared in order to determine the differences among the samples. The comparison of different degrees of beating of the same pulp was simplified by arbitrarily taking the adsorption from a solution of initial concentration 0.04 gram per liter Benzo Fast Scarlet 4BSA as the "specific dye adsorption" for the sample. This simplification was justified because of the simplicity and similarity of the isotherms for the pulps concerned.

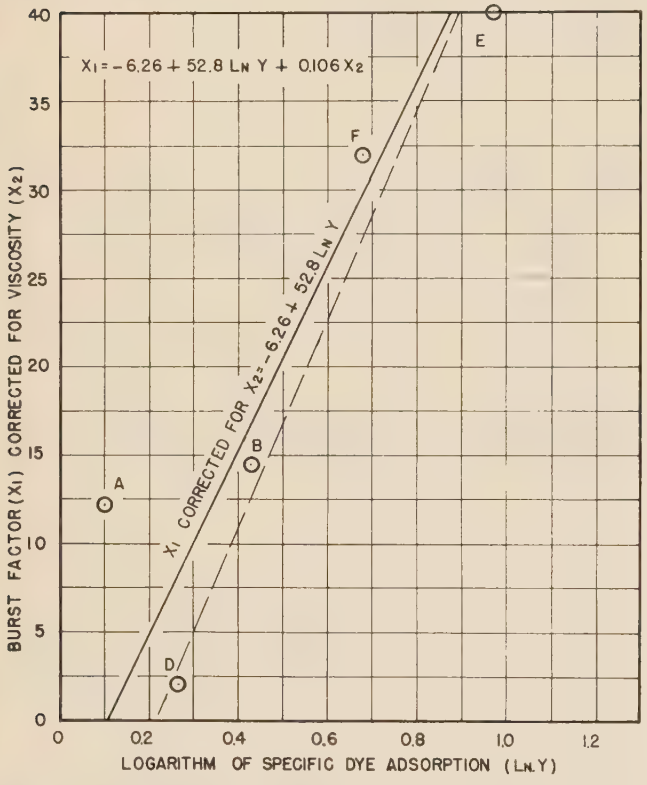

Fig. 3. Burst factor corrected for CED viscosity versus the natural logarithm of specific dye adsorption of various unbeaten sulphite pulps

It was soon discovered in the present investigation that the isotherms for the different pulps studied varied quite significantly. As may be seen in Fig. 1, where several representative isotherms are plotted, a real question arises as to what number may be used to indicate the external specific surface of the pulp. This is because the representation of each individual curve by a single number is not possible when one plots isotherms in the customary form of $x/m = f(c_f)$.

It is possible, however, to plot the data in the form of $c_i/m = f(c_f/m)$, as shown in Fig. 2. The straight line portions of the curves so obtained are essentially parallel with the different intercepts representing the different surface areas of the adsorbent pulps. The convention was thus adopted for this paper of reporting such intercept as the "specific dye adsorption."*

CORRELATION OF DATA

After all observations had been completed, there were but six samples of bleached softwood sulphite pulp for which good data were available. They were: (a) calcium-base dry lap, 5 years old; (b) calcium-base wet lap, fresh; (c) calcium-base Mitscherlich wet lap, fresh; (d) magnesium-base dry lap, 2 years old; (e) ammonia-base wet lap, fresh; and (f) sodium-base wet lap, fresh.

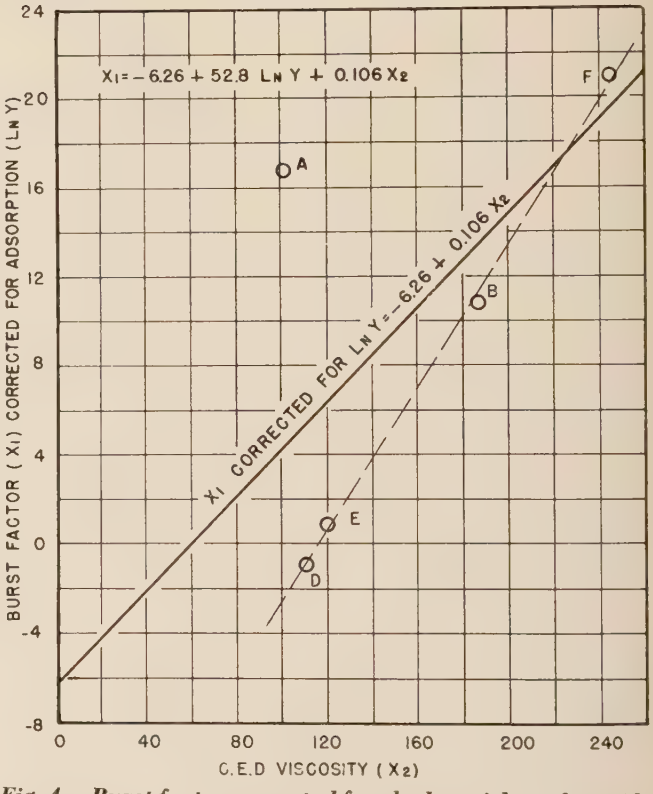

Fig. 4. Burst factor corrected for the logarithm of specific dye adsorption versus CED viscosity of various unbeaten sulphite pulps

* *Note:* The reader will note that $\lim_{c_f \to 0} x/m = c_i/m(k)$. Thus the newly advanced definition of specific dye adsorption retains the same dimensions as the older one. Furthermore, the two are identical for isotherms of the Langmuir type, with straight portions that are horizontal.

Table I gives a summary of test data on unbeaten and beaten samples of these six pulps.

On the assumption that bursting strength is a function of molecular weight (as indicated by the CED viscosity) and of external specific surface (as indicated by specific dye adsorption) an attempt was made to determine the linear relation among burst factor, CED viscosity and specific dye adsorption. A standard method of linear correlation as described by Ezekiel (*2*) was used. (See also article by F. L. Riley (*4*).)

By assigning the following notation:

Burst factor	X_1
CED viscosity	X_2
Natural log of specific dye adsorption	ln Y

an equation representing X_1 as an estimated function of X_2 and Y may be written:

$$X_1 = A + B \ln Y + CX_2 \qquad (1)$$

The constants in this equation may be evaluated by the method of least squares. When this was done for the data on unbeaten pulps, the following equation was obtained:

$$X_1 = -6.26 + 52.8 \ln Y + 0.106X_2 \qquad (2)$$

Since the equation so developed is a linear equation in three variables, it represents a plane, not merely a line. Thus the usual test for scattering of data may not conveniently be applied, as in the latter case. If, however, one makes an appropriate choice of mathematical planes (namely, planes perpendicular to the plane of the equation) on which to lay out coordinate axes, one may obtain the projection of the plane of the equation as a straight line on rectangular coordinates.

The axes of two such planes may be so chosen that the abscissa of each is one of the two independent variables (X_2, ln Y) and the ordinate of which is the dependent variable corrected for the other of the independent variables ($X_1 - B \ln Y$, $X_1 - CX_2$).

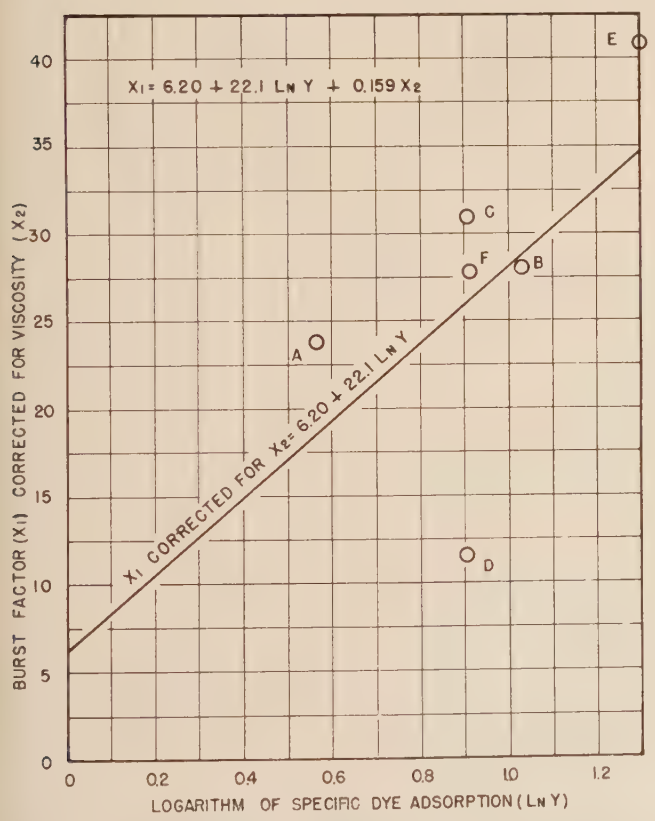

Fig. 5. Burst factor corrected for CED viscosity versus the natural logarithm of specific dye adsorption for various beaten sulphate pulps

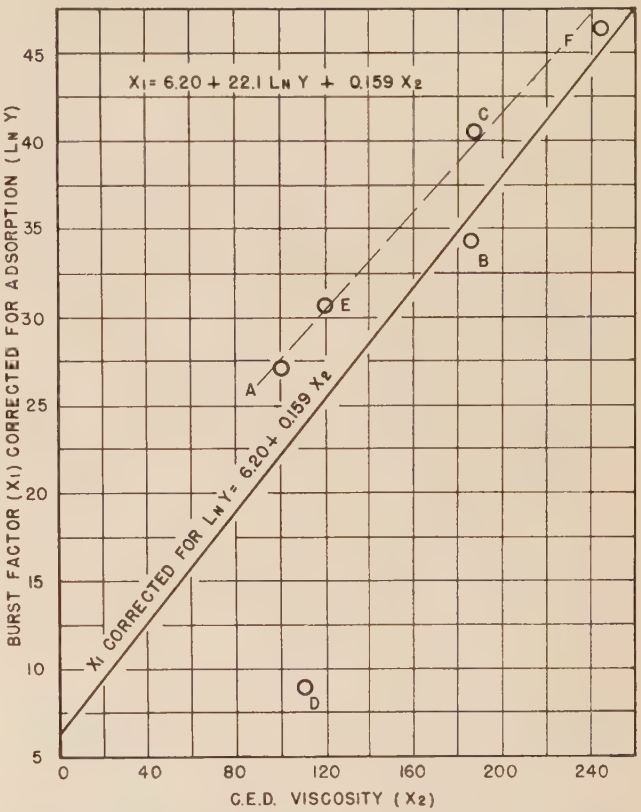

Fig. 6. Burst factor corrected for the logarithm of specific dye adsorption versus CED viscosity of various beaten sulphite pulps

Figures 3 and 4 are two such graphs prepared to show the scatter of data from which equation 2 was derived. In Fig. 3, for example, the experimental burst data are corrected for the influence of CED viscosity in accord with the statistically derived equation and are plotted as a function of the natural logarithm of dye adsorption.

For the benefit of those not familiar with this method of data analysis, two points are noted: first, the basic equation (equation 2) is calculated on the assumption that a linear relation exists among the variables selected and that no other variable affects the relationship. Second, the correction of data points for comparison with the equation on rectangular coordinates does not prejudice the data, even though the constants of the assumed equation must be used in this correction. The adherence to or deviation from the line of the equation by observed data points has exactly the same significance as in the case of a simple linear equation in two variables.

INTERPRETATION OF RESULTS

As originally computed, the data for pulp C, the Mitscherlich, deviated widely from the other data on unbeaten pulps. It will be remembered that one of the variables considered to be important in paper strength was the chemical composition of the fiber sur-

face. There is much good evidence that the very outside of native wood cellulose fibers differs from straight cellulose; it is thought to contain a high percentage of mannan (*3*). This skin is very much subject to chemical and mechanical attack. Thus, it is reasonable to believe that the very mild Mitscherlich cook may disturb this skin much less than quick cooks. Because of this strong suspicion that an uncontrolled variable had interfered with the results, the data for pulp C were omitted in the computation of the constants shown in equation 2.

Upon examining Figs. 3 and 4, one may observe that both a solid and a dotted line are drawn in, as well as the data points. The solid line represents equation 2, while the dotted line has been arbitrarily included to emphasize the fact that four of the five data points fall on a single straight line. The fifth point, which deviates a considerable amount, is pulp A, the 5-year-old sample.

The implication of even this small body of data should be clear: over a wide range of wood species and pulping conditions, the bursting strength of unbeaten sulphite pulp is primarily a function of the molecular weight (degree of polymerization) of the cellulose and of the external specific surface of the fibers.

To the papermaker, the data on beaten pulps given in Figs. 5 and 6 may be of greater interest than the unbeaten pulp information. The Mitscherlich pulp was not omitted from this comparison because beating presumably destroys the skin that causes the difference in the unbeaten state.

While the scatter of points in Figs. 5 and 6 is more pronounced than in the case of data on unbeaten pulps, there is no doubt about the validity of the relations among burst, dye adsorption, and CED viscosity. In spite of an unaccountable deviation of one point, the import of the data clearly supports the thought that bursting strength is influenced primarily by molecular weight and surface area.

APPLICATION TO PULP QUALITY CONTROL

As our knowledge of the really basic phenomena of papermaking increases, there is a trend toward the greater use of chemical and physical predictive tests for pulp quality control. It is to be hoped that some measure of the external specific surface of pulp may be included among these.

When considering strength and other performance properties that may be required of, say, a blend of pulps, one might presume that such intrinsic factors affecting quality as the average molecular weight and the average specific surface may have additive effects. Thus, it is reasonable to expect that the performance of a blend of pulps (as regards strength properties) may be predicted from a knowledge of the CED viscosities and specific dye adsorption values for the individual pulp varieties. (In some cases a knowledge of molecular weight distribution may be required to make this prediction accurate.)

Another possible prediction use of these tests may be found of value in the blending of chips for the digester charge. It should be possible for a given mill to obtain specific surface and molecular weight data on all the wood species commonly segregated in the wood room and to predict therefrom performance characteristics of pulps from blends of these woods. In the investigation here reported, wood from a variety of species was the fiber source, and, despite the diversity of cooking and bleaching conditions, variations in bursting strength were revealed by the cupriethylene viscosity and dye adsorption tests.

The above examples are but two illustrations of possible quality control uses of the dye adsorption test, or other indication of surface area, when used in conjunction with other measurements of fundamental significance.

ASSESSMENT OF THE DYE ADSORPTION TEST

This paper concludes the reporting of various aspects of a dye adsorption test for pulp evaluation. It was the original hope of the investigators that this test could be developed as a measure of the external specific surface of wood pulp. While it has been demonstrated that specific dye adsorption is basically connected with specific external surface, this test has not been perfected as an absolute measure of external specific surface. Despite this disadvantage, the writers feel that the dye adsorption test provides a sufficiently good indication of the external specific surface to merit its use in pulp evaluation.

In previous papers it has been shown that changes in specific dye adsorption are related to the changes in the strength properties of a given pulp which occur as a result of beating, bleaching, and drying. In this paper it has been shown that the specific dye adsorption may be used to correlate the strength properties of a variety of pulps, if correction is made for the effect of molecular weight. This information clearly indicates that the dye adsorption test measures a factor of fundamental importance in the bonding of fibers to form paper.

CONCLUSIONS

Results herein presented indicate that, irrespective of source, the bursting strength of sulphite cellulose is largely determined by the degree of polymerization of the cellulose and the external specific surface of the fibers.

It is concluded that the dye absorption test is of potential value in pulp quality control to give quantitative indication of changes in specific external surface.

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In bringing this series to a close the senior author wishes to thank Lyle C. Jenness and Ashley S. Campbell of the University of Maine and Harry F. Lewis and John L. Parsons of TAPPI for their thoughtful consideration in providing the support without which this work could not have been performed.

Accelerated Aging of Record Papers Compared with Normal Aging

WILLIAM K. WILSON, JACK L. HARVEY,
JOHN MANDEL, and THELMA WORKSMAN

In 1928 the National Bureau of Standards tested a series of commercial writing papers before and after accelerated aging for 72 hr. at 100°C. and stored additional specimens of the papers in a bookcase in an office for future testing in order to compare the results of accelerated aging with natural aging. Specimens of these papers were tested for 4 and 8 years of natural aging. The chemical tests were again repeated after 22 years and the physical tests after 26 years, and the complete test data are given in this paper. There appears to be a fair correlation between natural aging and accelerated aging. From a statistical analysis of part of the folding endurance data, a crude approximation of the relationship between accelerated aging and natural aging was obtained. While the data in this paper permit qualitative conclusions, no quantitative conclusions can be drawn, as the manufacture and testing of paper had not progressed far enough in the late twenties to permit the proper control of variables in the selection of samples.

The Paper Section of the National Bureau of Standards published in 1929 a description of an accelerated aging test for paper (*1*). Several physical and chemical tests were made on a group of commercial papers, before and after accelerated aging, and the remaining papers were then stored for future testing in order to establish a basis for comparing the accelerated aging test with natural aging. Reports have been made on tests after 4 years and 8 years of natural aging (*2*, *3*). This paper is a report on a retest of the papers after 22 to 26 years' storage.

In the report on the tests after 8 years' storage it was concluded that (1) the papers were grouped in the same relative order of stability by their retention of folding endurance during the natural-aging period and under accelerated aging by heating for 72 hr. at 100°C., and (2) there was good correlation between the chemical properties of the papers and their stability. The chemical properties referred to are alpha-cellulose, copper number, and acidity.

SAMPLES STUDIED AND METHODS OF ANALYSIS

The papers included in the study were mostly commercial writing papers ranging in fiber furnish from 100% rag to 100% sulphite. Four soda-sulphite book papers were also included. They were stored in an office bookcase and were not exposed to unusual conditions of temperature, humidity, or air pollution.

The papers were tested again for folding endurance (Schopper—10 strips in each direction); tensile strength (10 strips in each direction); water-soluble acidity (Kohler-Hall), (triplicates); pH (duplicates); alpha, beta, and gamma-cellulose (duplicates); and copper number (duplicates). All tests were made by TAPPI Standard methods except as noted below.

A gravimetric method for alpha-cellulose was used when the papers were first analyzed and again after 4 years' storage, and a volumetric method (TAPPI T 429) was used after 8 and 22 years' storage. The two methods have been reported to give good agreement (*4*, *5*). Beta and gamma-cellulose and pH were determined at the 8 and 22-year periods only.

The present TAPPI method "Water-Soluble Acidity or Alkalinity of Paper" T 428 m-45, specifies one extraction with water at 98 to 100°C. All of the data in this paper and in previous papers were obtained from three extractions.

The test specimens were conditioned to 65% R.H. at 23°C. for all physical test data reported in this series of papers.

RESULTS AND DISCUSSION

Table I contains chemical test data and Table II contains physical test data on the comparison of natural aging with accelerated aging of papers. The original test values are given in each case except for pH and beta and gamma-cellulose. Chemical test data were obtained after 4, 8, and 22-year periods, and the changes are expressed in the same units as the original values. Tensile and folding endurance were obtained after 4, 8, and 26 years, and are expressed as percentage retention of the original values.

As the experiment did not originally have the benefit of statistical design in the modern sense, the remarks in this section are made from an inspection of the data and not from statistical analysis. A statistical analysis of part of the folding endurance values is given in the next section.

The papers as a group are more acid than would be considered desirable today for record papers. The pH values are mostly within the range of 4.0 to 4.6, hot extraction, with the exception of papers nos. 114, 117, 782, 147, and 152. The change in pH between 8 years and 22 years appears to be insignificant for the rag papers, the part rag papers, and the purified sulphite papers. The sulphite papers as a group appear to show a definite decrease in pH.

The increase in total acidity resulting from accelerated aging seems to correlate well with the increase due to 22 years of natural aging. The purified sulphite papers as a group and the soda-sulphite papers, nos. 147 and 152, show a remarkably small change for both types of aging.

The copper number changes appear to show fair correlation between accelerated aging and 22 years of natural aging.

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Table I. Chemical Test Data on Naturally Aged and Artificially Aged Papers

Sample no.	Kind of fiber: Rag	Coniferous	Deciduous	Kind of sizing	Alpha-cellulose, %: Original value	Decrease after 72 hr., 100°C.	Decrease after 4 yr.	Decrease after 8 yr.	Decrease after 22 yr.	Beta-cellulose, %: Value at 8 yr.	Beta-cellulose, %: Increase, 22 yr. minus 8 yr.	Gamma-cellulose, %: Value at 8 yr.	Gamma-cellulose, %: Increase, 22 yr. minus 8 yr.	Copper no.: Original value	Copper no.: Increase after 72 hr., 100°C.	Copper no.: Increase after 4 yr.	Copper no.: Increase after 8 yr.	Copper no.: Increase after 22 yr.	Total acidity[a], %: Original value	Total acidity[a], %: Increase after 72 hr., 100°C.	Total acidity[a], %: Increase after 4 yr.	Total acidity[a], %: Increase after 8 yr.	Total acidity[a], %: Increase after 22 yr.	pH: Cold extraction: Value at 8 yr.	pH: Cold extraction: Decrease at 22 yr.	pH: Hot extraction: Value at 8 yr.	pH: Hot extraction: Decrease at 22 yr.
All-Rag Papers																											
114	100	..	..	Rosin	99.0	1.0	0	0	−0.1	0.5	−0.5	0.5	0.4	0.30	0.08	0.11	0.10	0.04	0.014	0.000	0.000	0.00	−0.01	6.1	−0.5	5.7	0.3
118	100	...	..	Rosin & glue	95.1	0.6	0	−1.8	−1.2	1.5	−0.4	1.6	1.0	0.88	0.04	...	0.62	0.27	0.169	0.016	0.000	0.02	−0.01	4.6	0.0	4.1	0.2
119	100	..	..	Rosin	92.9	5.6	0	0.4	3.1	4.5	2.7	3.0	0.2	1.28	0.46	0.03	0.32	0.52	0.086	0.043	0.010	0.05	0.06	5.0	0.4	4.4	0.2
120	100	..	..	Rosin & glue	94.4	1.3	0	0.6	0.8	3.6	−0.2	2.6	0.4	1.11	0.26	...	0.19	−0.03	0.090	0.042	0.011	0.05	0.05	4.8	0.0	4.3	0.2
127	100	...	..	Rosin	91.1	3.1	0	−0.5	−1.4	4.2	−1.3	4.2	0.4	0.93	0.78	...	0.27	0.47	0.138	0.045	0.000	0.01	0.03	5.0	−0.6	4.2	−0.2
126	100	...	..	Rosin & glue	94.4	2.1	0	0.5	−0.5	1.6	−0.9	4.5	−0.1	1.23	0.39	...	0.77	0.19	0.235	0.046	0.000	0.04	0.03	4.8	−0.1	4.3	−0.1
129	100	..	..	Rosin	92.2	5.2	0	−0.5	−1.6	3.1	−0.9	4.2	−0.2	1.03	0.61	...	0.17	0.31	0.120	0.060	0.016	0.04	0.06	4.9	−0.3	4.2	0.0
128	100	..	..	Rosin & glue	94.3	2.5	0	−0.5	−1.5	1.4	−0.8	3.8	−0.2	1.12	0.16	...	0.18	0.28	0.218	0.039	0.000	0.04	0.05	4.7	−0.3	4.0	0.0
131	100	..	..	Rosin	83.9	4.8	0	3.3	1.5	16.5	−2.3	2.9	0.5	2.26	0.52	0.05	0.04	0.32	0.075	0.056	0.021	0.04	0.06	5.1	−0.3	4.6	−0.2
130	100	..	..	Rosin & glue	86.6	2.3	0.2	2.4	1.1	13.4	−1.3	2.4	0.0	2.48	0.23	...	0.12	0.25	0.084	0.048	0.022	0.04	0.04	5.1	−0.4	4.6	−0.1
Rag Sulphite																											
111	60	40	..	Rosin	82.0	6.4	1.3	4.6	4.4	...	−1.0	..	0.8	3.24	0.57	0	0.06	0.03	0.076	0.051	0.017	0.04	0.04	4.9	0.2	4.4	0.2
112	60	40	..	Rosin & glue	81.8	5.2	1.4	3.7	4.0	...	−0.4	..	0.7	3.39	0.42	0	−0.09	−0.10	0.119	0.043	0.000	0.02	0.02	4.7	0.1	4.3	0.0
133	65	35	..	Rosin	79.0	4.5	0.0	4.7	5.1	...	0.4	..	0.0	2.31	1.50	0.09	1.09	1.42	0.055	0.049	0.017	0.03	0.06	5.1	0.0	4.5	0.0
132	65	35	..	Rosin & glue	80.2	3.8	0.4	5.9	6.2	...	0.3	..	0.0	3.38	0.53	...	0.12	0.62	0.079	0.047	0.000	0.02	0.04	5.2	0.0	4.5	0.1
Purified Sulphite																											
105	..	100	..	Rosin & glue	90.5	1.0	0	0.5	1.5	...	−0.5	..	1.5	1.40	0.32	0.06	0.10	0.16	0.092	0.050	0.000	0.04	0.05	4.5	0.2	4.1	0.2
106	..	100	..	Rosin & glue	88.8	1.7	0	2.0	0.8	...	−2.5	..	1.3	1.37	0.35	0.11	0.43	0.29	0.063	0.031	0.001	0.05	0.03	5.1	−0.2	4.5	0.1
107	..	100	..	Rosin & glue	88.3	1.7	0	1.2	1.7	...	−0.6	..	1.1	1.78	0.20	0.0	0.12	0.16	0.114	0.028	0.000	0.04	0.00	5.1	−0.3	4.2	0.2
782	..	100	..	None	90.5	0.3	0	2.2	0.1	...	−2.0	..	0.1	0.67	0.14	...	0.10	0.25	0.016	0.000	...	0.00	−0.01	6.1	−0.5	5.2	−0.3
Sulphite																											
108	..	100	..	Rosin	77.8	4.4	2.0	5.9	9.1	...	1.2	..	2.0	4.89	0.46	0.0	0.41	0.48	0.108	0.056	0.037	0.09	0.08	4.9	0.3	4.2	0.2
109	..	100	..	Rosin	77.2	3.2	1.5	4.6	6.5	...	0.4	..	1.5	4.78	0.49	0.0	0.12	0.40	0.084	0.071	0.033	0.14	0.09	4.8	0.7	4.3	0.6
110	..	100	..	Rosin	81.6	5.2	1.3	2.5	4.8	...	0.8	..	1.5	3.77	0.55	0.0	0.03	0.56	0.113	0.014	0.024	0.08	0.07	4.7	0.7	4.4	0.4
116	..	100	..	Rosin	76.4	6.0	1.3	2.4	5.7	...	3.2	..	0.1	4.27	0.51	0.0	0.23	0.71	0.119	0.075	0.000	0.04	0.05	4.9	0.8	4.4	0.6
117	..	100	..	Rosin	80.6	3.5	1.0	1.3	3.0	...	2.0	..	−0.3	2.98	0.59	...	−0.18	0.56	0.033	0.023	0.030	0.07	0.04	5.4	0.4	5.3	0.3
134	..	100	..	Rosin	79.9	3.2	0.6	3.0	3.9	...	1.2	..	−0.3	3.75	0.36	...	0.15	0.77	0.082	0.058	0.034	0.07	0.06	5.0	0.0	4.3	0.2
135	..	100	..	Rosin	79.2	3.2	..	1.6	4.9	...	3.5	..	−0.2	3.29	0.80	...	0.31	1.25	0.066	0.031	0.032	0.03	0.03	5.0	−0.2	4.7	−0.1
Soda-Sulphite																											
123	..	65	35	Rosin	74.0	5.0	0	10.9	15.1	...	4.3	..	−0.1	3.72	0.40	...	0.68	1.18	0.085	0.072	0.032	0.06	0.07	5.0	0.2	4.3	0.3
124	..	50	50	Rosin	63.8	5.3	0	5.4	10.5	...	6.8	..	−1.7	5.19	0.19	0.12	0.41	0.96	0.095	0.067	0.033	0.09	0.06	5.1	0.3	4.4	0.4
147	..	35	65	Rosin	77.9	0.2	0	1.0	1.4	...	0.6	..	−0.2	2.29	0.06	0.0	0.41	0.44	0.038	0.010	0.011	0.01	0.01	6.5	−0.2	6.1	0.2
152	..	25	75	Rosin	78.8	0.3	0	1.0	1.3	...	0.4	..	−0.1	2.55	0.10	...	0.05	0.19	0.031	0.011	0.020	0.01	0.02	6.5	−0.2	5.9	0.4

[a]Expressed as per cent SO_3.

The decrease in alpha-cellulose caused by accelerated aging for the rag papers is fairly definite, but with the exception of no. 119, the decreases after 22 years of normal aging are negligible. The remainder of the papers show good correlation between accelerated aging

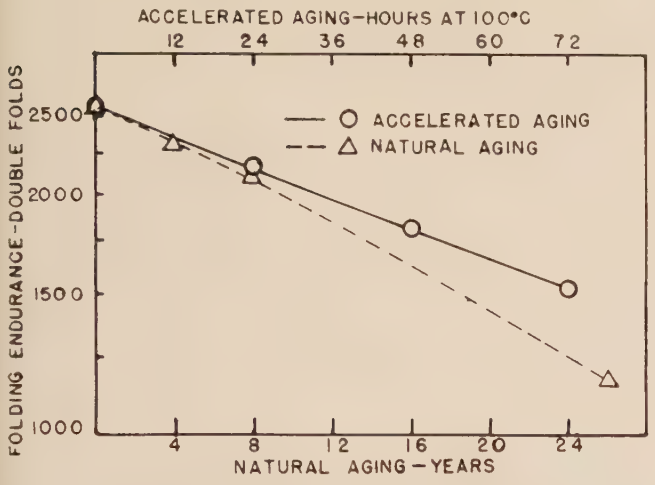

Fig. 1. Change in folding endurance of new rag papers due to accelerated aging and to natural aging

and 22 years of natural aging. The sulphite paper, no. 108, and the soda-sulphite papers, nos. 123 and 124, decreased in alpha-cellulose content much more after 22 years' natural aging than upon accelerated aging.

The soda-sulphite papers show an interesting contrast in extent of degradation, apparently caused by differences in acidity. With pH values (cold extraction) of 5.0 and 5.1, nos. 123 and 124 show alpha-cellulose decreases of 15.1 and 10.5%, respectively, after 22 years. With pH values of 6.5, nos. 147 and 152 decreased in alpha-cellulose content 1.4 and 1.3%, respectively, after 22 years. The copper number changes are also much greater for nos. 123 and 124 than for nos. 147 and 152. These data show that papers with low alpha-cellulose contents may be stable if the pH is sufficiently high. In a study of the effect of accelerated aging on book papers, papers with low acidity showed good stability regardless of alpha-cellulose content, and papers containing calcium carbonate were most stable of all (*6*).

The changes in gamma-cellulose from 8 years to 22 years are very small and are probably within the limits of experimental error. The decreases in alpha must then be reflected as increases in beta. This has been noted by others in cellulose degradation studies (*3, 6*).

Some materials exhibit an induction period when subjected to accelerated aging (*7–10*), the first part of the aging period showing little measurable change. To determine whether 25 years of natural aging might have served as an induction period with the result that the papers would be much less stable toward accelerated aging, representative papers were heated 72 hr. at 100°C. and the changes in alpha-cellulose determined. The data are given in Table III. Most of the changes in alpha-cellulose owing to accelerated aging for the two groups of papers agree within the limits of experimental error. The differences are not considered significant.

STATISTICAL ANALYSIS OF THE DATA

Analysis of Variance

It must be realized that the experiment in question was started 26 years ago. Information regarding details of design and method of carrying out the experiment is only partially available. Consequently, analysis of the data can only lead to tentative, or, at best, incomplete conclusions.

The only data that seemed to warrant a statistical analysis were those on folding endurance on the new rag* and on the sulphite papers.† A preliminary study of the data indicated the likelihood that the loss in folding endurance during any period of time was related to the folding endurance of the material at the start of the period. Consequently, the analysis of variance was carried out on the logarithm of folding endurance. A summary of the analyses, for new rag and for sulphite, is given in Table IV. The assumption underlying the analyses is that variation in the results is due to differences in the original folding endurance of the samples, to the type and duration of aging, and to uncontrolled fluctuations.

In Table IV, the effects of the two types of aging, natural and artificial, are combined in a single mean square, and the uncontrolled fluctuations are measured by the mean square denoted by "Remainder." The latter will be required for an appraisal of the reliability of the curves discussed in the following section.

Aging Curves

On the basis of the data listed in Table II, aging curves were drawn, both for natural and accelerated

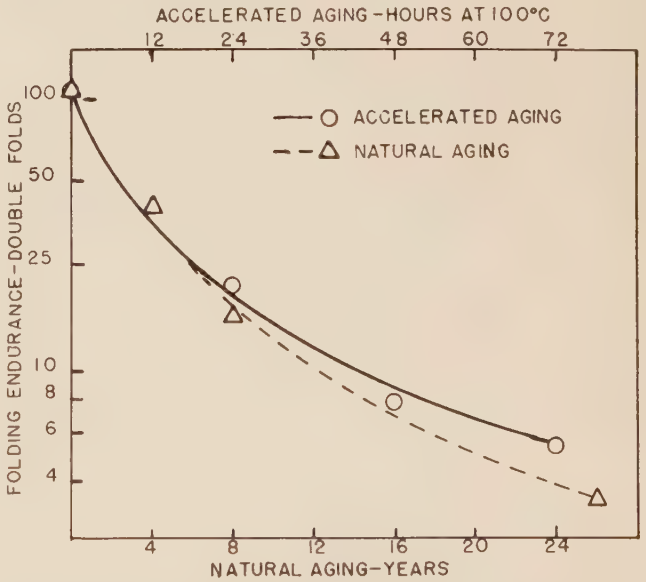

Fig. 2. Change in folding endurance of sulphite papers due to accelerated aging and to natural aging

aging, using a logarithmic scale for folding endurance. The curves are shown in Figs. 1 and 2 and are based on the logarithmic averages of the values corresponding to all the papers in the group. In the case of the sulphite stock, considerable curvature is observed despite the

* Samples 114, 118, 119, 120, 127, 126, 129, and 128.
† Samples 108, 109, 110, 116, and 117.

Table II. Physical Test Data on Naturally Aged and Artificially Aged Papers

Sample no.	Kind of fiber: Rag	Kind of fiber: Coniferous	Kind of fiber: Deciduous	Kind of sizing	Folding endurance: Original values: Machine direction, double folds	Folding endurance: Original values: Cross direction, double folds	Folding endurance: Retention[b] after: 24 hr., 100°C., %	Folding endurance: Retention[b] after: 48 hr., 100°C., %	Folding endurance: Retention[b] after: 72 hr., 100°C., %	Folding endurance: Retention[b] after: 4 yr., %	Folding endurance: Retention[b] after: 8 yr., %	Folding endurance: Retention[b] after: 26 yr., %	Tensile strength: Original values: Machine direction, kg.[a]	Tensile strength: Original values: Cross direction, kg.[a]	Tensile strength: Retention[b] after: 72 hr., 100°C., %	Tensile strength: Retention[b] after: 4 yr., %	Tensile strength: Retention[b] after: 8 yr., %	Tensile strength: Retention[b] after: 26 yr., %
All-Rag Papers																		
114	100	..	..	Rosin	1665	439	101	85	79	94	91	31	7.1	4.4	105	105	100	
118	100	..	..	Rosin & glue	4656	6193	71	69	76	109	84	72	11.2	8.2	97	109	124	
119	100	..	..	Rosin	2557	1668	73	42	22	65	62	29	9.1	5.1	98	101	100	
120	100	..	..	Rosin & glue	3639	2814	96	80	82	106	84	57	11.3	7.4	94	105	102	
127	100	..	..	Rosin	3337	1246	80	75	70	80	80	47	9.4	5.5	101	97	103	
126	100	..	..	Rosin & glue	2985	1929	88	90	77	104	84	50	11.5	6.9	100	99	100	
129	100	..	..	Rosin	3117	2606	75	64	58	85	81	48	8.8	5.7	106	105	99	
128	100	..	..	Rosin & glue	3499	2628	90	84	69	86	95	44	11.3	6.2	102	108	106	
131	100	..	..	Rosin	9	9	73	68	63	72	81	64	5.3	4.0	106	100	94	
130	100	..	..	Rosin & glue	22	20	86	73	53	93	71	51	7.0	5.1	106	105	95	
Rag Sulphite																		
111	60	40	..	Rosin	102	71	53	48	24	63	39	25	7.6	4.5	97	100	95	
112	60	40	..	Rosin & glue	206	107	33	31	16	56	28	15	8.4	4.4	93	104	97	
133	65	35	..	Rosin	337	191	..	..	15	59	34	15	8.6	4.9	92	93	91	
132	65	35	..	Rosin & glue	339	172	..	..	17	66	23	14	9.0	5.4	93	94	89	
Purified Sulphite																		
105	..	100	..	Rosin & glue	1420	800	75	..	54	58	40	38	8.2	5.1	100	100	96	
106	..	100	..	Rosin & glue	2465	1560	73	..	71	79	52	41	10.3	5.2	100	102	94	
107	..	100	..	Rosin & glue	1855	1180	74	76	56	79	63	50	11.4	5.3	103	107	100	
782	..	100	..	None	4420	5480	..	..	96	89	91	44	8.2	5.4	106	103	99	
Sulphite																		
108	..	100	..	Rosin	15	17	34	16	10	45	16	1	6.7	3.0	110	92	98	
109	..	100	..	Rosin	49	22	39	12	9	35	14	7	7.6	3.0	100	104	81	
110	..	100	..	Rosin	529	249	8	3	1	36	14	1	8.6	4.6	87	100	83	
116	..	100	..	Rosin	501	364	12	3	3	21	8	5	9.5	5.1	97	98	84	
117	..	100	..	Rosin	150	157	30	14	12	62	29	18	7.8	4.2	92	100	92	
134	..	100	..	Rosin	510	191	..	..	1	56	16	11	8.0	4.7	81	95	88	
135	..	100	..	Rosin	106	72	..	..	6	40	21	7	7.2	3.3	95	105	92	
Soda Sulphite																		
123	..	65	35	Rosin	4.8	4.0	..	..	35	75	46	38	4.6	2.5	101	108	86	
124	..	50	50	Rosin	2.4	1.9	..	..	48	79	50	..	4.3	2.3	95	102	82	
147	..	35	65	Rosin	15.7	5.6	..	..	64	73	68	61	5.8	2.8	96	96	93	
152	..	25	75	Rosin	8.9	6.5	..	..	69	87	75	65	5.9	3.1	100	102	91	

[a] Breaking load, 15-mm. strips.
[b] Average for 10 specimens in each direction.

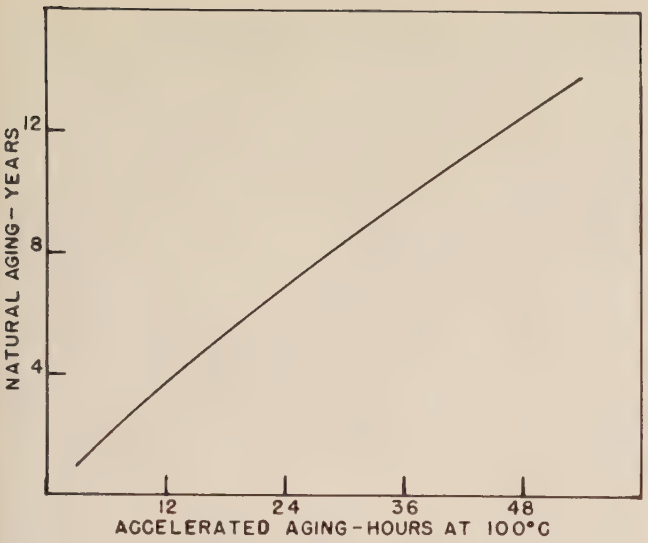

Fig. 3. Relationship between accelerated aging and natural aging for new rag papers

use of the logarithmic scale. The same pattern was observed for the old rag and rag-sulphite samples (curves not included), indicating that the relative loss in folding endurance for these materials was most severe in the early stages of aging. The new rag samples do not show this tendency to the same extent.

From the curves in Figs. 1 and 2 a relationship between accelerated and natural aging can be evaluated, by finding the periods of accelerated and of natural aging that result in the same loss in folding endurance. The results are shown in Figs. 3 and 4. It must be emphasized that these curves can only be considered as rather crude approximations; they are based on the curves in Figs. 1 and 2, which were drawn free-hand through at most four experimental points.

Limitations

Only in the case of new rag and sulphite, for which analyses of variance could be made, are some objective measures of precision available. In the case of new rag, the uncertainty of each point of Fig. 1 is characterized by a coefficient of variation of about 7% in each direction (i.e., for natural and for accelerated aging). In the case of sulphite the corresponding coefficient of variation is as large as 30%. In addition to this error there is the uncertainty introduced by the smoothing of the experimental points necessary to obtain the relationships shown in Figs. 3 and 4. No objective measure is available for the possible errors resulting from this treatment of the data.

Table III. Effect of Accelerated Aging on Alpha-Cellulose Content of Original Papers and of Papers After 26 Years' Storage

Sample No.	*Kind of fiber*	*Alpha-cellulose value in 1928, %*	*Decrease in alpha-cellulose after 72 hr. at 100°C. In 1928, %*	*In 1954, %*
114	New rag	99.0	1.0	1.5
118	New rag	95.1	0.6	2.2
127	New rag	91.1	3.1	3.9
131	Old rag	83.9	4.8	5.6
782	Purified sulphite	90.5	0.3	1.0
108	Sulphite	77.8	4.4	3.5
117	Sulphite	80.6	3.5	1.5
124	Soda-sulphite (50–50)	63.8	5.3	4.9
152	Soda-sulphite (75–25)	78.8	0.3	3.1

Table IV. Analyses of Variance on Logarithm of Folding Endurance

Source of variation	*Sulphite* — *Degrees of freedom*	*Sulphite* — *Mean square*	*New rag* — *Degrees of freedom*	*New rag* — *Mean square*
Samples	4	1.755	7	0.272
Aging conditions	6	1.604	6	0.185
Remainder	24	0.098	42	0.025

CONCLUSIONS

With the exception of folding endurance, a statistical analysis of the data was not performed. It appears, however, that there is a fair correlation between natural and artificial aging. While this is qualitatively a valuable conclusion, no quantitative conclusions can be drawn from this experiment since the manufacture and testing of paper had not progressed far enough in the late twenties to permit the proper control of variables in the selection of samples and since the relation between accelerated aging and natural aging is, in all likelihood, a function of these variables.

Any consideration of the permanence of paper must take into account the stability of the cellulose and the stability of the sheet formation. Chemical tests would be a measure of cellulose permanence, while physical tests would be a measure of the permanence of the paper (*11*). Cellulose permanence would be independent of the paper formation, but paper permanence would be dependent both on cellulose stability and on the permanence of sheet formation. Chemical test data in Table I on the rag papers indicate very little deterioration in 22 years, but the folding endurance has decreased on the average, to less than half of the original value.

As the tensile strength did not change appreciably due to either type of aging, it appears that tensile is not particularly sensitive to the type of changes which occur

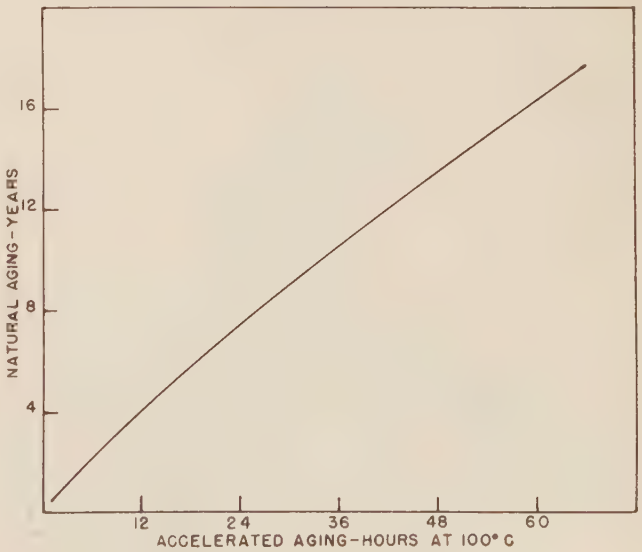

Fig. 4. Relationship between accelerated aging and natural aging for sulphite papers

in papers due to natural or accelerated aging, within the time limits of these experiments.

As the folding endurance decreases sharply for all types of papers, it is apparent that changes occur in the fatigue characteristics of the papers but not in strength. This could conceivably be due to an increase in crystallinity of the cellulose or to a relaxation of some of the secondary valence forces. These changes might occur upon heating, or over a long period of time at room temperature, especially with the great number of changes in moisture content which occur on natural aging. A set of papers stored in an air-conditioned building for 15 years showed very little change in folding endurance (*12*). This does not prove that changes in moisture content affect the fatigue characteristics of papers, but it does suggest a possibility for further research.

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High-Yield Sulphite Pulping

Part VI. Cohesive Rating: An Index of the Ease of Fiberizing

J. M. WOODS and J. S. HART

Measurement of the material binding fibers together in a high-yield pulp (i.e., a lignin determination) is not necessarily a measurement of the fiberizing quality of that pulp. Other factors such as the method of cooking require consideration as influences on the ease of fiberizing. This physical property of a high-yield pulp is called its "cohesiveness" and "the cohesive rating" is a numerical figure which expresses the measurement of that property in a standard procedure devised for this purpose. The development of an apparatus and procedure is described in this paper. The apparatus consists of a laboratory dynopulper which has been modified to give reproducible results. The procedure consists essentially of processing the pulp in this dynopulper for a specified time and then fractionating it on an appropriate screen to determine the per cent rejects. Details of the procedure as recommended for mill operations are given in the Appendix. This measurement may be of use as a mill control test. Thus far, the test provides results which are relative rather than absolute. Close correlation has been found in the laboratory between the cohesive rating and the refining energy under standard refining conditions, but there is a need for additional information from mill experience with this method as to correlations of cohesive rating with refining to a required pulp quality for any particular mill. A valuable, absolute test which would serve as a tool for research and control may be evolved in time from mill use of the techniques described herein.

Semichemical pulping processes have received a great amount of attention in recent years. The development of high-yield kraft pulping and of the neutral sulphite semichemical (NSSC) process for hardwoods have been proceeding rapidly. Paralleling this development of processes has been an increasing variety of uses for the pulps. However, a reliable means for evaluation of the high-yield product as it comes from the digester, in terms that can be related closely to the power requirements for subsequent fiberizing,* have not previously received adequate attention. Most mills have used tests which are concerned with the amount of lignin remaining in the high-yield residue. It was recognized, generally, that such tests could only be correlated very roughly with the requirements for fiberizing the residue, or pulp, in subsequent refining. Hence, a feature of the high-yield sulphite pulping program at the Pulp and Paper Research Institute of Canada has been the evolution of a method for measuring the fiberizing qualities of semichemical pulps.

After a limited amount of chemical treatment, such as would obtain in a high-yield or semichemical cook, the individual fibers forming a wood chip are generally still attached to each other, but not as firmly as in an untreated chip. The cohesive forces are probably primarily dependent upon the amount of binding material that remains after the treatment. These forces will, therefore, vary with the severity of the conditions which have effected the removal of some of the wood constituents. Thus, at any period of chemical treatment prior to the actual separation of a chip into individual fibers through chemical removal of the binding materials, there is a force which holds the fibers together in the chip. This property of the chip (or of the partially fiberized residue which comes from the digester) may be referred to as its "cohesiveness."

A quantitative determination of the binding material, or lignin, in the chip or residue will not, necessarily, reflect the true measure of the cohesiveness of that product. This is because a good deal will depend upon the location and nature of that lignin. And this may, in turn, be influenced very considerably by the method of pulping.

The Institute reasoned that by subjecting the chip, or pulping residue, to controlled mechanical action for

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* Commonly and erroneously called "defibering."

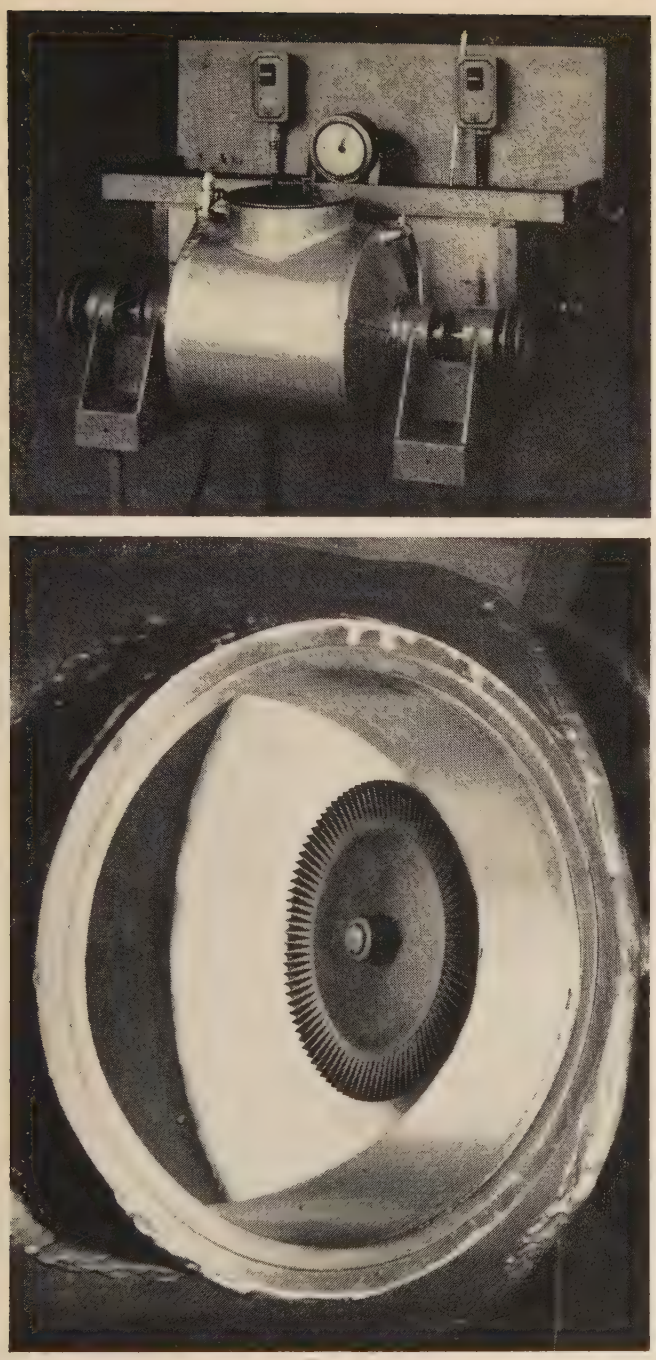

Fig. 1

a standard period of time, then screening the product in a standard way and determining the fractions, a reproducible means could be found for measuring the cohesiveness of the components of the cooked charge, as this is expressed by the ratio of the stock accepted to the stock rejected on a specific screen. The measurement (i.e., the quantitative value) of this ratio (or property) of the cooked charge could then be termed the "cohesive rating."

Earlier, the Institute had already used this principle to a limited extent for evaluating high-yield pulps. The partially cooked chips were treated in the disintegrator of the standard sheet-making apparatus under a given set of conditions and then screened. The rejected fraction was expressed as a percentage of the original weight. Thus, a measure of the cohesiveness was determined. This procedure worked well; but the size of the sample was limited, and more efficient ways for conducting the test were needed.

It was learned early in 1952 that the Hammermill Paper Co. was using the laboratory dynopulper in its research laboratory for the evaluation of semichemical pulps. The procedure was similar to that being used at the Institute; but the dynopulper appeared to be better adapted for this work than is the smaller disintegrator. It was decided, therefore, to investigate this machine as a possible apparatus for measuring routinely the cohesive rating of semichemical pulps.

DEVELOPMENT OF APPARATUS

The first step was procurement of a laboratory dynopulper from the Rice Barton Corp. of Worcester, Mass. This machine consists of two rotors situated at opposite ends of a cylindrically shaped tank and rotating in opposite directions. These rotors or impellers have a slightly dished shape and an apparently random distribution of irregularly shaped particles brazed on the concave face. The particles appear to be pieces of tool steel. When the machine is operating, the chips or chip fragments (or fiber bundles) are drawn in toward the center of the disk and pass outward across the projecting particles, leaving the disk at the circumference. The action upon the chips or fragments is, therefore, probably confined for the most part to mechanical impact.

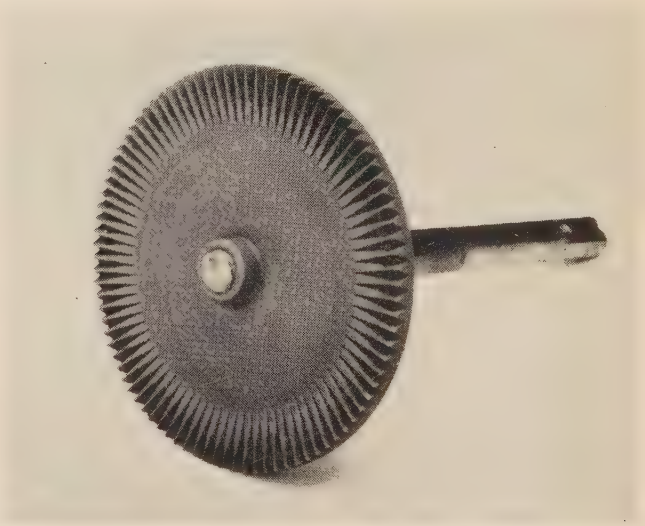

Fig. 2

This apparatus was tested very thoroughly and it was evident that some correlation between time of treatment in the dynopulper and the per cent rejects was obtainable but that the degree of correlation was not of the desired order. There appeared to be a number of uncontrolled variables contributing to this inaccuracy, a major one being the "blinding" of the impellers because chips became stuck on the surface. This resulted in smoothing the effective profile of the projecting particles and diminishing its action on the pulp. Other effects were also observed, and the following changes were then incorporated in a redesign of the apparatus as shown in Fig. 1.

1. A cast pulley was substituted for the variable-speed pulley on the drive of each impeller.
2. The size of the pulley was arranged to give a 1:1 ratio, resulting in an impeller speed of 1700 to 1800 r.p.m. At this speed no settling of chips in the early stages of the operation was noted, while at the same time there was insufficient turbulence to cause frothing.
3. The bearings were changed from wood to Oilite to prevent seizing and redesigned to act as thrust bearings. The packing glands were improved to eliminate leakage.
4. The impellers were machined to a definite pattern, shown in Fig. 2. These were made from barstock, hot-rolled, mild steel, $4^5/_8$-in. diameter. There is a total of 90 teeth with an angle of tooth equal to 45° included angle on the cutter. The length of tooth is $^3/_4$-in. Angle to the face is 15°. The edges are milled and two flingers are welded on the back of the impeller to prevent pulp from collecting between it and the casing. After machining, the impellers are case-hardened. The shafts are of stainless steel.

EVOLUTION OF PROCEDURE

The procedure used for testing the apparatus followed, in general, that of the Hammermill Paper Co. A known weight of partially cooked chips was placed in the machine and water was added to give a required consistency. The machine was operated for a certain

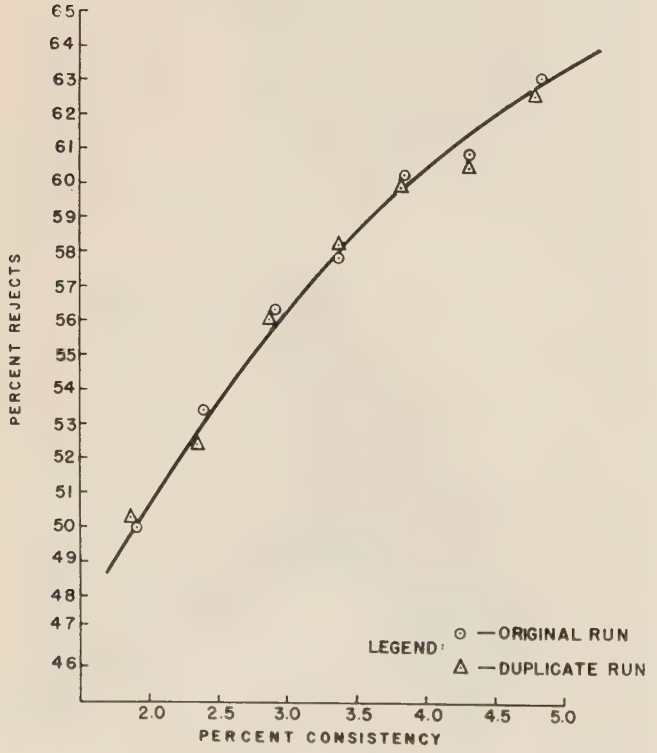

Fig. 3. Cohesive rating—variation of per cent rejects with consistency of charge, treatment time 32 min.

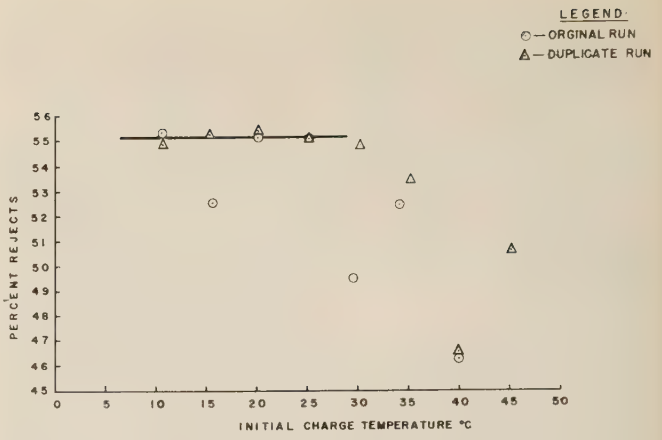

Fig. 4. Cohesive rating—variation of per cent rejects with initial charge temperature, treatment time 32 min.

number of minutes, following which the contents were removed and washed through a $^1/_4$-in. mesh screen. The rejects were weighed, and this weight was expressed as a percentage of the original weight. After making the changes to the apparatus mentioned in the preceding section of this paper, such a procedure gave excellent reproducibility of results under identical operating conditions.

The following paragraphs describe the effects of changes in the operating conditions on the results obtained. Their influence in the evolution of a preferred procedure will be obvious to the reader.

Screen Dimensions

The first procedure for separating the treated pulp into two fractions was to wash it through a $^1/_4$-in. mesh screen. Actually, this was done by dumping the pulp on the screen and using a stream of water from a hose to wash through all the pulp which could pass the $^1/_4$-in. openings. With pulps of very high yield, and even with those of not so high a yield, but which had received a shorter treatment in the dynopulper, this technique gave results of good reproducibility. However, for pulps so low in rejects after treatment that most of the charge would pass through the screen, the reproducibility of results with samples from the same pulp was not good. Therefore, a laboratory flat screen was fitted up with a screen plate having slots 0.013 in. in width. After the required time in the dynopulper, the stock was screened to rejection. This technique has been followed in all the trials reported herein, although it is recognized that, for some purposes, larger or smaller screen openings might be used to advantage.

Consistency of Charge

To evaluate the effect of consistency, a series of runs in duplicate was made. In each of these the total weight of stock was constant but the weight of moisture-free fiber used and the volume of water were varied. The results are tabulated in Table I and shown graphically in Fig. 3.

It is seen that consistency has a marked effect on the amount of rejects. This was to be expected; and, in the lower consistencies the effect was aggravated by foam generated during the operation. Extensive frothing had also been observed, in earlier trials, when the volume of water was insufficient to cover the impellers.

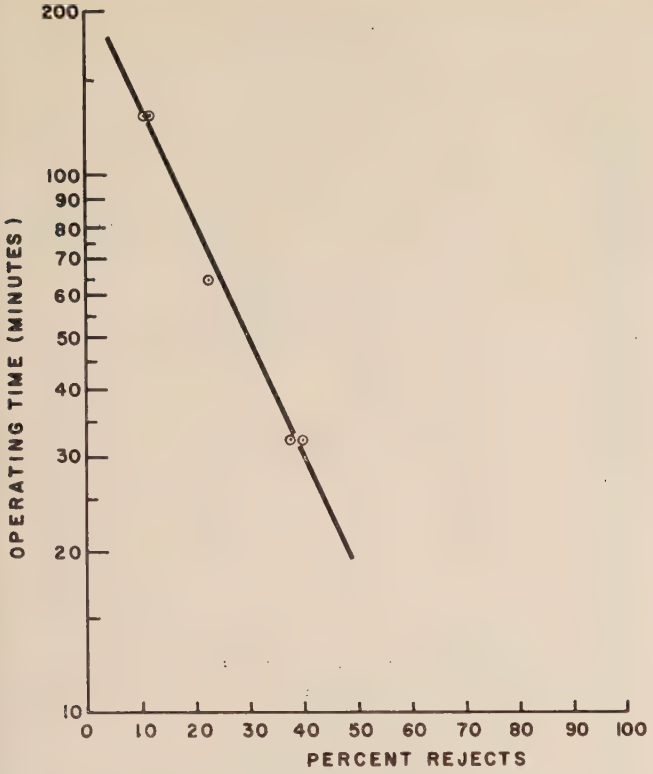

Fig. 5. Cohesive rating—per cent rejects versus log of operating time (NSSC pulp)

This emphasized the need for keeping the dynopulper completely filled with water to minimize the production of foam.

On the other hand, it may be seen that for each consistency investigated, the results showed good reproducibility.

Size of Charge

A charge of 454 grams moisture-free (1 lb.) yields sufficient pulp for a beater run when one is required. Also, with this weight of fiber and with complete filling with water, the consistency in the dynopulper is 3.5%. This value gives good reproducibility for duplicate tests and was chosen for all subsequent runs.

Estimation of Charge

At the beginning of the investigation, the practice was to determine the moisture content of a sample of the high-yield pulp, either by oven-drying or by the standard toluene procedure. Then, knowing the moisture content, an amount containing 454 grams moisture-free was weighed out. Later, this procedure was modified. Making an initial run with a charge approximating the required weight, the fractions were dried after screening and the original consistency was determined. Then the final run was made with the exact weight calculated from the consistency thus determined. This procedure did not add appreciably to the time. It had the advantage of permitting prediction of the optimum time for the final run from the results of the initial run.

Table I. Cohesive Rating—Variation of Per Cent Rejects with Consistency of Charge

(Treatment time—32 min.)

Run no.	Consistency, % moisture-free	Rejects, %	Temperature, °C. Initial	Final
3DR-28	1.91	50.0	11.5	13.0
29	2.39	53.4	11.0	13.0
30	2.90	56.3	11.0	13.5
31	3.35	57.9	11.0	13.5
32	3.84	60.2	12.0	14.0
33	4.30	60.8	12.0	14.0
34	4.83	63.0	12.0	14.0
35	1.88	50.2	16.0	18.0
36	2.35	52.4	17.0	19.5
37	2.86	56.0	16.5	19.5
38	3.36	58.0	17.0	19.5
39	3.80	59.9	17.0	19.5
40	4.31	60.5	17.0	18.5
41	4.80	62.6	17.0	18.0

Table II. Cohesive Rating—Increase of Temperature with Time of Operation

Run no.	Time, min.	Consistency, % moisture-free	Temperature, °C. Initial	Final
3DR-2	8	3.23	9.0	11.5
3	16	3.18	10.0	15.0
4	32	3.24	8.5	22.5
5	64	3.29	9.0	31.0
6	128	3.23	9.5	43.0
8	8	3.50	8.0	10.5
9	16	3.38	9.5	17.0
10	32	3.37	12.0	24.5
11	64	3.31	21.5	42.0
12	128	3.33	16.0	48.5
46	8	3.20	9.0	13.5
47	16	3.12	8.5	17.0
48	32	3.07	8.5	21.5

Temperature of Charge

In the duplicate series to investigate the effect of consistency (see above), the initial and final temperatures were recorded. These are shown in Table I. It is seen that there was only a small temperature rise during the 32-min. run. In some cases, however, where the time in the dynopulper was prolonged, it was thought

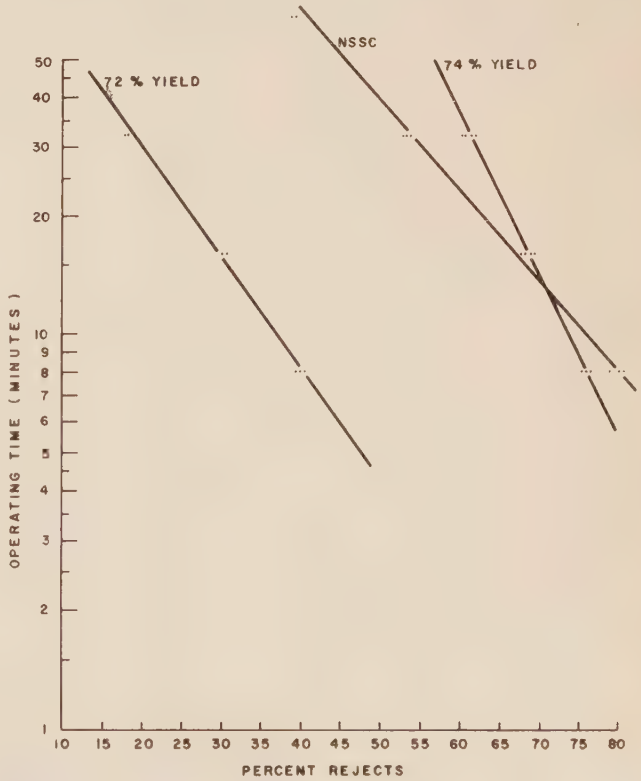

Fig. 6. Cohesive rating—per cent rejects versus log of operating time (high-yield sulphite and NSSC pulp)

Table III. Cohesive Rating—Variation of Per Cent Rejects with Initial Charge Temperature

(Treatment time—32 min.)

Run no.	Consistency, % moisture-free	Rejects, %	Temperature, °C. Initial	Final
3DR-13	3.31	55.3	10.5	24.0
14	3.09	52.5	15.5	29.0
15	3.34	55.1	20.0	32.0
16	3.35	55.1	25.0	36.0
17	3.23	49.5	29.5	40.0
18	3.33	52.4	34.0	44.0
19	3.29	46.3	40.0	50.0
20	3.20	55.0	10.5	22.5
21	3.29	55.2	15.0	29.0
22	3.35	55.3	20.0	31.0
23	3.34	55.1	25.0	36.0
24	3.35	54.8	30.0	40.0
25	3.31	53.4	35.0	43.5
26	3.29	46.5	40.0	49.0
27	3.29	50.6	45.0	53.0

that the final temperature could be a factor which would affect the degree of disintegration. Consequently, a series of runs was made to ascertain the temperatures to be expected from varied operating times. These are shown in Table II.

It is seen that with prolonged times (above 32 min.) there is a pronounced rise in temperature.

To find the effect of higher temperatures on the degree of disintegration, a duplicate series was run in which the initial temperatures varied between approximately 10 and 40°C. The results are tabulated in Table III and shown graphically in Fig. 4.

It is seen that the reproducibility is good and that the deviation from the mean is small at the lower initial temperatures; but that above 25°C. the results are erratic. Since, generally, samples are tested for less than 32 min. and, therefore, elevated temperatures will not occur as a result of the operation, and since initial temperatures below 25°C. give good reproducibility, no effort is made to control the temperature. Cold

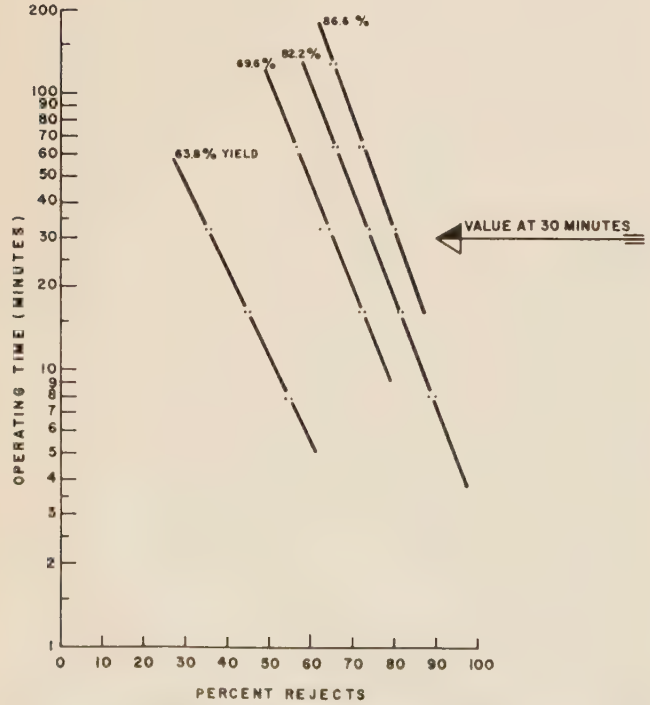

Fig. 7. Cohesive rating—high-yield sulphite pulp from spruce balsam

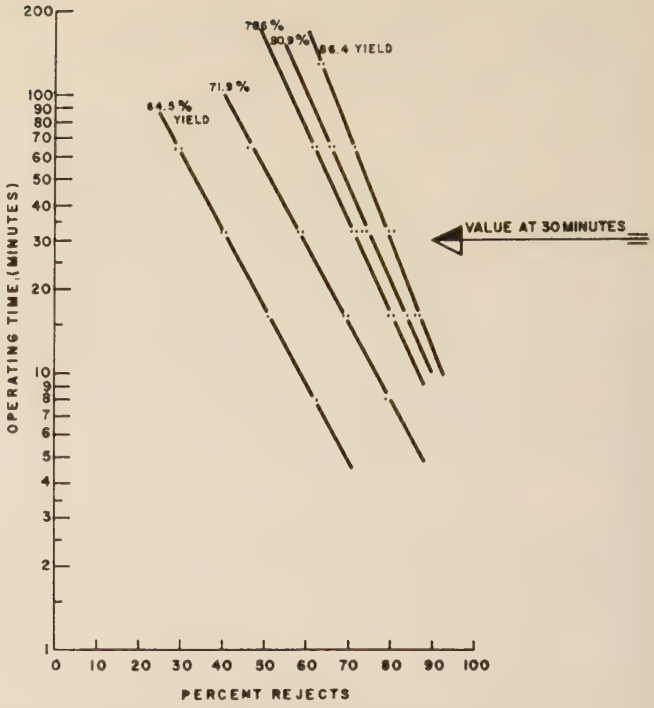

Fig. 8. Cohesive rating—high-yield sulphite pulp from western hemlock

water is used for dilution and consistent results on duplicate runs are obtained.

EVALUATION OF RESULTS

Cohesive Rating as a Mill Control Test

It has been demonstrated that treatment in a properly designed dynopulper for a specified time gives excellent reproducibility of results when the rejects from the screening operation are expressed as a per cent by weight of the untreated pulp. Increasing the time of treatment changes the per cent rejects and Fig. 5 shows a plot of per cent rejects against the log of various treatment times. The pulp in this case was a neutral sulphite pulp from hardwood. A straight-line relationship is indicated, even with extended treatment times of 128 min.

Figure 6 shows per cent rejects versus log time curves for two high-yield sulphite pulps and one NSSC pulp. The two high-yield sulphite pulps are from softwoods (mostly spruce balsam in each case) and have nearly the same yield (72 and 74%). Both were cooked in the vapor phase after being impregnated with a sodium-base acid. However, the acid concentration and the cooking times and temperatures were different in each case. This is reflected by the two widely spaced curves. Since they are closely parallel, however, the parallelism may indicate either a similarity of process, or of wood, or, perhaps, a combination of both.

The NSSC curve, on the other hand, has a different slope. It is to be noted that, at 8 min. treatment, the per cent rejects is greater than for the 74% yield sulphite. However, for 32 and 64 min., respectively, the percentages of rejects are less. Therefore, it appears probable that the *slope* of the per cent reject line, as well as its *value* at any given time, are significant when comparing the cohesive ratings of a variety of high-yield pulps.

Figure 7 shows curves for four high-yield sulphite

Table IV. Cohesive Rating—High-Yield Sulphite Pulp from Spruce Balsam

Yield, %	Run no.	Temperature, °C. Initial	Temperature, °C. Final	Consistency, % moisture-free	Time, min.	Rejects, %	Regression line Slope	Regression line Intercept[a]	Refining energy, hp.-days/ moisture-free ton
86.6	4DR-9	9.5	21.5	3.32	64	71.7			
	10	9.5	24.0	3.62	128	66.0			
	11	9.0	19.0	3.71	32	80.2			
	12	9.0	22.0	3.65	64	72.4			
	13	9.0	19.5	3.64	32	80.3			
	14	9.0	25.5	3.61	128	65.0	−4.07	80.7%	32.3
69.6	15	12.0	21.0	3.41	32	62.4			
	16	9.5	16.0	3.53	16	72.0			
	17	10.0	15.0	3.39	64	56.7			
	18	9.0	19.0	3.45	32	64.2			
	19	9.0	16.0	3.49	16	72.7			
	20	9.0	18.5	3.41	64	56.6	−3.80	64.8%	19.2
82.2	21	8.0	12.0	3.59	8	89.0			
	22	7.0	14.0	3.55	16	81.6			
	23	7.0	18.5	3.53	32	74.4			
	24	7.0	16.0	3.45	64	65.6			
	25	7.0	12.0	3.56	8	87.0			
	26	7.0	15.0	3.55	16	81.3			
	27	7.0	19.0	3.52	32	74.1			
	28	7.0	17.0	3.48	64	65.9	−4.06	74.4%	27.4
63.8	29	7.5	11.0	3.55	8	55.5			
	30	6.0	12.0	3.47	16	45.1			
	31	8.0	20.0	3.42	32	35.0			
	32	6.0	10.5	3.53	8	54.7			
	33	6.0	12.0	3.43	16	44.3			
	34	6.0	17.0	3.48	32	35.7	−3.03	36.1%	10.1

[a] At 30 min.

pulps, all made in the laboratory from the same wood (a spruce-balsam mixture) with the same procedure except for variations in pH of the cooking acid to produce the various yields. The detailed results are contained in Table IV. It may be seen that all curves are substantially parallel. Therefore, the value at a specified time (e.g., 30 min.) would be sufficient for mill control, without considering the slope. This is substantiated by the results shown in Table V and Fig. 8. The curves in this latter case represent various yields of a high-yield sulphite pulp from western hemlock, and the procedures were similar to those used for spruce balsam. The values at a given time could again be used as a mill control without reference to the slope.

Table V. Cohesive Rating—High-Yield Sulphite Pulp from Western Hemlock

Yield, %	Run no.	Temperature, °C. Initial	Temperature, °C. Final	Consistency, % moisture-free	Time, min.	Reject, %	Regression line Slope	Regression line Intercept[a]	Refining energy, hp.-days/ moisture-free ton
86.4	6DR-1	11.5	17.0	3.53	16	86.0	−3.82	79.4	25.5
	2	12.0	22.0	3.51	32	80.0			
	3	12.0	22.0	3.46	64	71.1			
	4	11.5	24.0	3.48	128	62.3			
	5	12.0	18.0	3.55	16	85.3			
	6	12.0	20.0	3.50	32	79.3			
	7	12.0	25.0	3.53	64	71.1			
	8	12.0	28.0	3.47	128	62.9			
64.5	9	7.0	12.0	3.50	8	62.4	−2.74	41.2	13.8
	10	5.0	12.5	3.44	16	50.7			
	11	5.0	17.0	3.35	32	39.6			
	12	7.0	12.0	3.50	8	62.4			
	13	5.5	13.5	3.42	16	50.8			
	14	5.0	16.5	3.38	32	40.4			
	15	5.5	17.5	3.36	64	29.8			
80.9	16	7.5	16.0	3.78	16	83.7	−3.29	75.1	22.9
	17	7.0	18.5	3.71	32	73.8			
	18	6.5	19.5	3.68	64	65.9			
	20	7.0	16.0	3.76	16	83.8			
	21	7.0	16.5	2.74	32	72.9			
	22	5.5	18.0	3.68	64	65.4			
71.9	24	8.0	13.5	3.58	8	78.7	−2.78	58.5	16.9
	25	7.5	13.5	3.54	16	69.6			
	26	9.0	18.5	3.52	32	58.4			
	27	8.5	15.0	3.55	8	78.4			
	28	7.5	13.0	3.48	16	68.7			
	29	7.5	17.5	3.47	32	57.6			
	30	8.0	19.5	3.40	64	45.5			
78.6	31	6.0	15.0	3.57	16	80.0	−3.25	71.6	21.0
	32	5.0	18.0	3.46	32	71.2			
	33	6.0	19.5	3.44	64	61.0			
	34	5.5	14.0	3.54	16	79.6			
	36	5.5	18.0	3.47	32	70.9			
	37	6.0	20.0	3.42	64	61.8			

[a] At 30 min.

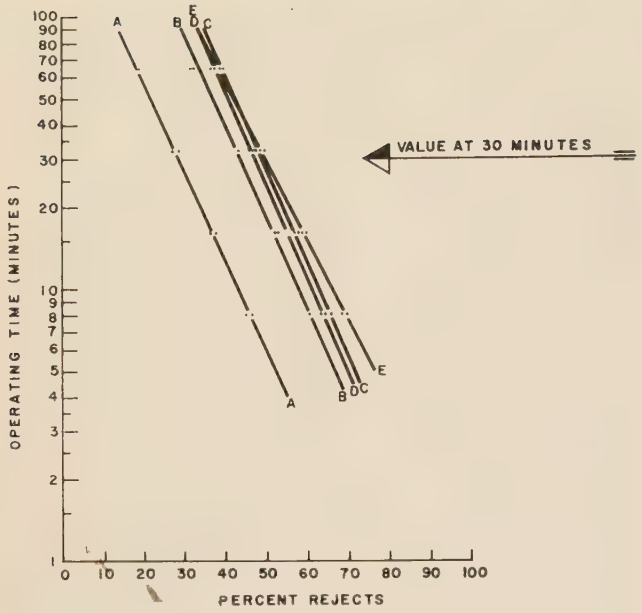

Fig. 9. Cohesive rating—high-yield sulphite, commercial pulp

This cohesive rating procedure was tested further through the cooperation of a mill† producing high-yield sulphite pulps. They undertook to send blowpit samples which represented individual cooks in each case. On arrival at the Institute, Roe chlorine numbers were determined and cohesive rating measurements were made at several time intervals. The results are shown in Table VI and Fig. 9.

The yields of these various pulps are not known for certain, but the value at 30 min. is seen to increase with increases in the chlorine number. Also, all the curves have very similar slopes, with the exception of sample E. This pulp had the highest Roe chlorine number, but the differing slope indicated some change, perhaps in the cooking conditions, or in the wood supply.

† Price Bros. & C o. Ltd., Riverbend, Que.

Cohesive Rating as a Fiberizing Index

A definite relationship should exist between the cohesive rating of a high-yield pulp and the energy required for fiberizing (i.e., separating into individual fibers from fiber bundles or from discrete chips or chip fragments). This would be generally useful for mill control purposes; but it would be even better suited for evaluating pulping methods in terms of the energy required for subsequent fiberizing in refining.

To test this relationship between cohesive rating as measured by the technique described in this paper and the power requirements for refining, the pulps produced in the Institute's laboratory digesters and also the commercial samples were treated in a 36-in. double-disk refiner under similar conditions. The results are listed

Table VI. Cohesive Rating—High-Yield Sulphite—Commercial Pulps

Pulp Sample	*Roe Cl_2 no.*	*Run no.*	*Temperature, °C. Initial*	*Final*	*Consistency, %*	*Time, min.*	*Rejects, %*	*Regression line Slope*	*Intercept at 30 min.*	*Refining energy, hp.-days/ moisture-free ton*[a]
A	19.0	5DR-9	8.5	11.5	3.54	8	45.0	−3.29	28.5	9.41
		10	7.5	12.5	3.48	16	36.4			
		11	7.0	16.0	3.52	32	27.1			
		12	7.0	25.0	3.44	64	18.3			
		13	7.0	9.5	3.50	8	46.3			
		14	6.0	11.0	3.46	16	37.7			
		15	7.0	15.5	3.55	32	28.4			
		16	5.0	26.0	3.47	64	18.6			
B	21.0	17	6.5	10.0	3.47	8	60.4	−3.17	43.2	11.1
		18	5.0	11.0	3.42	16	52.0			
		19	4.5	16.5	3.43	32	43.2			
		20	4.0	24.0	3.48	64	31.9			
		21	5.5	9.0	3.34	8	60.6			
		22	4.0	11.0	3.38	16	52.5			
		23	4.5	16.5	3.41	32	43.2			
		24	4.0	25.0	3.24	64	32.2			
C	23.8	25	5.5	9.0	3.51	8	65.7	−3.30	48.8	12.0
		26	3.5	9.5	3.46	16	57.7			
		27	3.5	14.5	3.42	32	48.6			
		28	4.0	24.0	3.38	64	39.3			
		29	4.0	9.0	3.43	8	65.8			
		30	4.0	10.0	3.36	16	57.6			
		31	4.0	15.5	3.38	32	47.5			
		32	4.0	25.0	3.38	64	37.9			
D	24.4	33	5.0	9.0	3.35	8	63.1	−3.31	47.2	11.0
		34	3.5	10.0	3.33	16	56.4			
		35	3.0	15.0	3.30	32	47.1			
		36	3.5	24.0	3.24	64	37.1			
		37	4.0	8.0	3.35	8	64.0			
		38	3.5	10.0	3.33	16	56.7			
		39	3.5	14.0	3 31	32	46.3			
		40	4.5	25.0	3.29	64	36.8			
E	25.0	41	4.0	10.5	3.46	8	69.2	−2.91	49.4	13.6
		42	4.0	16.0	3.45	16	59.3			
		43	4.0	16.0	3.42	32	49.9			
		44	3.5	25.5	3.42	64	38.0			
		45	4.0	10.0	3.50	8	68.3			
		46	5.0	12.0	3.40	16	58.0			
		47	3.5	16.5	3.45	32	48.5			
		48	3.5	24.0	3.42	64	37.5			

[a] Laboratory evaluation.

in Tables IV, V, and VI. The power requirements are plotted against the cohesive rating (30 min. intercept), and the curves for spruce balsam and western hemlock are shown in Fig. 10 and the one for the commercial high-yield sulphite is shown in Fig. 11.

It may be seen that there is a definite relationship between the cohesive rating and the energy requirements, the one increasing with the other. Moreover, it is apparent that the cohesive rating varies directly with increases in yield in the laboratory pulps. Hence, the cohesive rating as measured by a 30-min. intercept, might well serve, not only as a mill control test but also to indicate the refining energy requirements.

To the present time, all reported comparisons of cohesive rating and energy requirements have been made with pulps cooked by the same general process with only minor changes to produce variations in yield. Yet, the cohesive rating may also be used to evaluate pulps cooked by quite different means to give the same yield. This latter approach has been used by the Institute with excellent results. Differences in the cohesive rating values at a given time interval have been observed with pulps having the same yield and produced by various cooking procedures. Furthermore, when it is plotted against energy requirements obtained under similar refining conditions, the cohesive rating again shows differences. Thus, it appears that the cohesive rating may be used as an index of the ease of fiberizing, either for various yields of pulp produced from the same wood by a single type of cooking, or for the same yield of pulp produced by differing types of cooking.

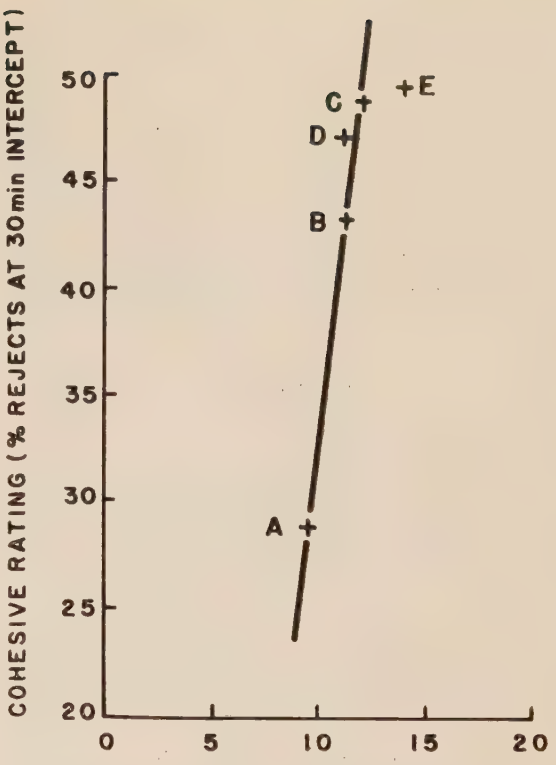

Fig. 11. Cohesive rating—cohesive rating versus refining energy (commercial pulp)

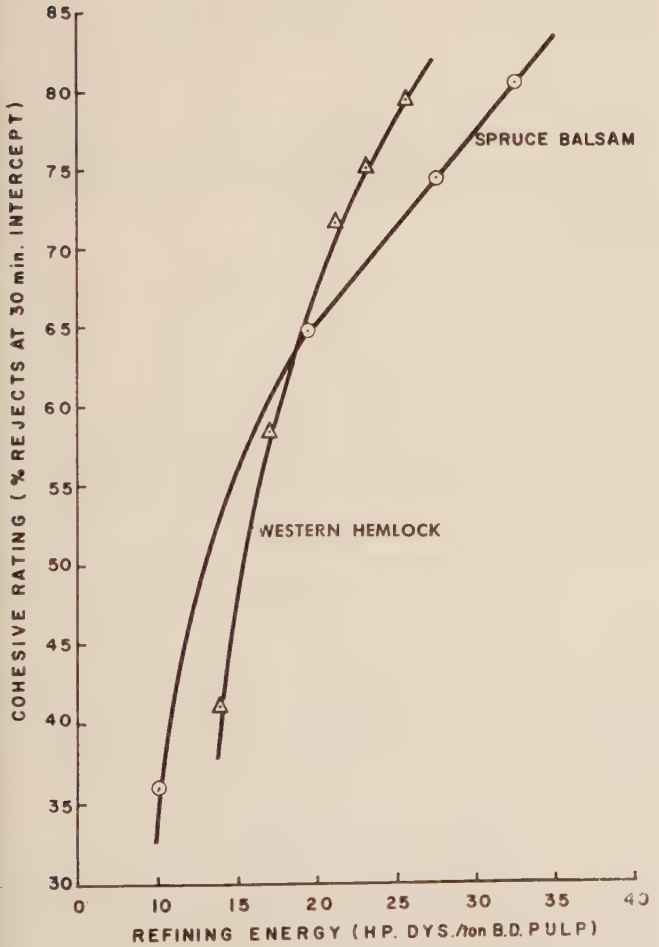

Fig. 10. Cohesive rating—cohesive rating versus per cent refining energy, spruce balsam and western hemlock

It is not yet known whether the same straight-line relationships or curves found in this study between the cohesive rating and the energy requirements under standard refining *conditions* will hold when the refining is carried out to some arbitrarily selected standard of *pulp quality* expressed in terms of the measurements of physical properties such as burst, stiffness, freeness, etc. Since the mills have varying standards and requirements as to these properties, and since their complement of refining equipment varies, the Institute suggests that each mill is in the best position to determine for itself that relationship—that is, between cohesive rating and power requirements to a standard quality. When this has been accomplished, it is believed that the cohesive rating may become for that mill an absolute index which can serve for research and control.

CONCLUSIONS

Measurement of the property of cohesiveness of a high-yield pulp by means of the standardized method described herein resulted in a reproducible value, termed the "cohesive rating." The procedure by which mills may apply these findings to their operations is detailed in the Appendix to this paper.

The method for using this measurement as an absolute one in the evaluation of high-yield pulps for any particular mill can only be found by that mill. At present, it would seem that the cohesive rating values obtained are relative—that is, when two high-yield or semichemical pulps are compared, their respective cohesive ratings may be merely an indication of the relative orders of magnitude of power required to fiberize

each to the same degree, rather than specific indices of the actual horsepower days per ton for each. Other physical or chemical factors, as yet not studied, may affect the *absolute* values. Moreover, it must be realized that the experiments described in this paper were, of necessity, limited to the use of a Bauer 36-in. refiner, which the Institute happened to have available. What the relationships with other types of refiner would be have not as yet been determined. Extension of this study to other types of refiner at a commercial scale is a problem for the industry, rather than for the Institute.

APPENDIX

Suggested Mill Procedure for the Determination of Cohesive Rating

From the work of the Hammermill Paper Co., supplemented by that of the Institute, it would appear that the following procedure should be followed by any mill which wishes to try out the usefulness of the "cohesive rating" as an index to the ease of fiberizing.

1. The high-yield chips to be tested should be mixed thoroughly and an amount containing approximately 450 grams moisture-free should be isolated for use in the test.

2. This sample should be placed in the dynopulper (modified as described in this paper) and water added until it is level with the bottom of the throat. (This results in a consistency of approximately 3.5%.) The dynopulper should then be started (both motors simultaneously) and stopped at intervals, in order to examine the rate of fiberizing. In this manner, suitable times of treatment for further runs can be judged. When the sample has been sufficiently fiberized to enable rapid drying to take place, the dynopulper should be stopped and the sample should be removed and filtered and its moisture determined. One or more samples, as required, should then be prepared, each containing 454 grams moisture-free.

3. A sample should be placed in the dynopulper and water added to the required level. (In Summer, it may be necessary to cool the water since the stock temperature should be approximately 10°C.) The motors should then be started and the machine run for the required length of time.

4. Upon completion of the run, the sample should be removed and screened to rejection on a 0.013-in. cut laboratory flat screen. The separate portions of accepted and rejected stock should be dried to constant weight in a hot-air oven and the per cent rejects calculated.

5. Generally, more than one run should be made, each with different operating times. These would then be plotted against the per cent rejects on semilogarithmic graph paper, and the resultant graph should approximate a straight line. The actual regression line, however, is best obtained by calculation. The slope and the intercept for a particular time should be recorded.

In order to find absolute values for the relationship of the cohesive rating to power requirements, which would be applicable to any particular mill, that mill should carry out subsequent refining under some standard set of refining conditions which are found to give a required pulp quality.

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Warehousing, Shipping, and Material Handling of Carton Packed Paper

S. W. BLANCHARD

A description of the new 216,000 sq. ft. warehouse for palletized paper at the Mead Corp. in Chillicothe, Ohio, is given. The location of items by rate of turnover rather than by grades was used to cut down the ton-mile haulage. Material handling equipment of fork lift walkie trucks for very short hauls, stand-up rider fork trucks for pick-ups, and an automatic pallet hoist for lowering loaded pallets from the second to ground floors is described. A brief description of order writing, manifest, and billing by use of business machine punched cards is given.

A description of the new carton stock warehouse at the Mead Corp. mill in Chillicothe, Ohio, is given together with the methods of stock placement, material handling, stock pick up, and shipping systems used.

The continued growth of our business resulted in our warehousing facilities becoming more and more inadequate at our Chillicothe Division. The roll storage warehouses were, fortunately, large enough to give adequate service but the carton warehouse was overtaxed resulting in one item being placed in front of another in storage which caused confusion, loss of some items, occasional shipment of a wrong item, and assorted troubles.

So, when management gave the go ahead to design a new warehouse, the operators, engineers, office system men, and staff planners all got together for a series of conferences to plan the best warehouse possible to handle carton paper on pallets. The result is a completely modern building, ideally suited to its purpose and capable of adjustment to meet changing conditions.

S. W. Blanchard, Vice President's Staff, Mead Corp., Chillicothe, Ohio.

TYPE OF WAREHOUSE

The type of service the warehouse was to be designed for had to be considered first. When the various grades, colors, weights, sizes and finishes were taken into account, it was found that about 1500 different items had to be accommodated. It was desired to have

a sufficient quantity in stock of each to be able to fill the everyday demand from customers "off the shelf." It was also necessary to be able to store a sufficient amount of one grade, weight, and color to allow scheduling economic size runs on the paper machine.

Bulk storage, like so much coal in a bin, while giving the greatest storage capacity per cubic foot, was obviously out as not giving possibility of customer service for the many items.

A producer's warehouse is essentially different in function from a merchandiser's warehouse. The merchandiser needs only to carry enough stock of any one item to meet expected orders over a short period of time and he can reorder as he wishes. The papermaker, however, not only has to stock all of his standard items for quick delivery but he has to be in a position to receive each item in relatively large quantities in order to permit reasonable manufacturing schedules. However, if sufficient space were permanently assigned to each item to take the maximum quantity made on one paper machine run, the space required would be tremendous. A large amount of the space would be empty all of the time and the distance covered in assembling an order would be extreme.

Our goal was to have a definite place where an item could always be found and which was so located, that when putting in stock or picking up a shipment, we could obtain the best possible ton-mile efficiency of the industrial trucks and the operators.

In making a layout to meet this we took a leaf from grocery warehouse practice and applied some of their basic principles to our problem (*1*).

The final plan resulted in practically all items having a standard place on the ground floor of the new building, which was also the shipping floor. The size of the space assigned varied with the activity of that particular item. In the case of slow movers the entire inventory would be carried in one small location on the ground floor which might last several months while the fast selling items might have an area several times as large but which would only last 2 or 3 days. These big volume items would have a "surge" or bulk storage on the second floor which would be used to replenish the ground or "order pick" floor as needed. The surge storage took the swing of the large runs from the paper machines in addition to servicing the ground floor. This surge had no permanent location assigned to any particular item. A space that had 16-lb. white bond in it one month might have colored ledger and mimeo in it the next month, etc. The method of keeping track of the quantity and location of the various items will be described later.

Single or Multi-floor Building

Several articles have appeared in the past few years describing various one-floor distributors' warehouses which have recently been erected to give excellent service. The one-floor plan appears best up to a certain area, after that size is passed, the multi-floor type will show less average ton-miles than the one floor plan. This is particularly applicable where vertical transportation can be made automatic. The horizontal travel distances are cut down in the multi-floor job and the vertical travel is relatively short and cheap if made automatic as it can be.

In our case we had an area 220 by 440 ft. to work in and needed more space than one floor so a two-story building was constructed. In the center of the area an automatic hoist with short receiving and delivering conveyors was placed. Paper is ream sealed and packed in cartons on the second floor and loaded on pallets by production crews. The warehouse trucker picks up the load, when ready, with a fork truck, takes it to the warehouse receiver who has his standup desk beside the hoist. The receiver checks the contents of the load and marks on it the face and bay where it is to be delivered. The trucker sets the load down on the conveyor and goes off after the next load. The conveyor starts, delivers the load onto the hoist which then goes down and discharges the load onto a receiving conveyor on the ground floor where a receiving trucker picks it up and puts it in the marked location. The hoist is also arranged with a conveyor on each floor for bringing piles of empty pallets up from the ground to second floor. The entire operation is automatic (see Fig. 1).

Layout of Ground Floor and Assignment of Permanent Spaces

The ground floor has a 440-ft. side on the north which faces on a street. Eight truck doors open onto this street with space for each to receive an entire tractor with its trailer inside. These loading docks are alternated every other day which leaves a vacant space between each dock for the accumulation of shipments. The truck doors are of the steel roll-up type, electrically operated from inside the warehouse. They are numbered inside and out and lighted for clear visibility at night. Midway of the truck doors is a truckers' entrance leading to a room with chairs and table with adjoining toilet and shower. When a trucker arrives he goes into the truckers' room and calls the shipping office on the phone, they tell him which door his shipment is collected at and open that door for him to back his truck in. The doors are equipped with photoelectric beams so that the doors cannot be closed when a truck, or anything is in the way (see Fig. 2).

Part of the ground floor is given over to an employees' locker room, time and personnel office, etc., but the major part is available for cartonned paper storage on pallets.

Every 3 months the statistical department issues a report showing tons sold and number of shipments of each item. These reports are used to determine the activity of an item and the relative amount of inventory that should be carried. Aisles were laid out with different amounts of space between them so that different sized areas could be allocated conveniently. The largest space accommodates four pallet loads wide, six deep, and two high or about 48 tons. The smallest space allocated is for $^1/_2$ ton which would be for a very slow moving item.

In our previous warehouse the paper had been stored by grade and subdivided by weight, size, color, etc., a system easily learned by the truckers but one that required constant trucking of fast movers past slow items with resultant high ton-mile hauling. In the new layout the fast movers were put near the heart of operations and the slow movers put around the outskirts regardless of grade, weight, color or size.

It was found desirable to also make a classification by size of carton or pallet in order to facilitate picking up and shipping. For example, all the bond folio sizes, $8^1/_2$ by 11, 17 by 22, 22 by 34, and 34 by 44 are packed on a pallet approximately 36 by 48 in. These

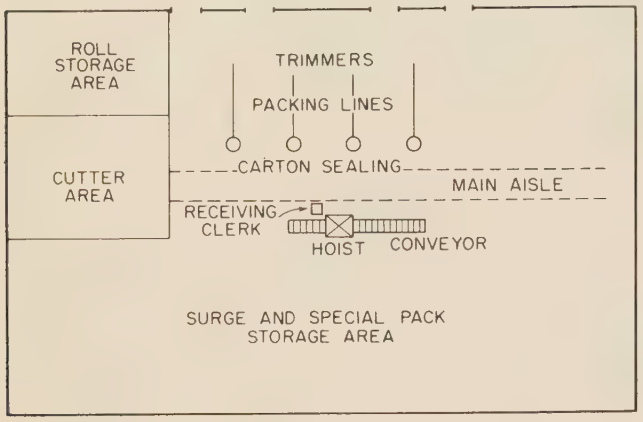

Fig. 1. Functional sketch of second floor carton paper warehouse

size pallets are all grouped in one general area with the most active nearest the heart of operations. The 19 by 24 and 24 by 38 are grouped together as are the $8^1/_2$ by 14, 17 by 28, and 28 by 34 family. The reason for this is for efficiency in assembling an order for shipping. The order department releases "get out" sheets for a shipment which is given by the foreman to a pick-up man with a fork truck. For items of full pallet loads only one man is needed on the truck. Where the order calls for two cartons of this, three of that, one of the other etc., two men ride the truck. The trucker will first start to pick out all the items fitting one size pallet and will accumulate a load. By having all of one size pallets in one area two advantages are gained: (1) the work is condensed into a relatively small area for any given trip of pick-up crew; and (2) the load is a solid block of cartons of even or multiple sizes which facilitates loading and decreases damage in transportation (see Fig. 3).

There are eight main longitudinal aisles running length-wise of the floor with two main cross aisles running in the other direction and connecting with roll storage, rail shipping, and other buildings on the south. Smaller subsidiary aisles are used where advantageous to make the best use of space. Instead of numbering each aisle, each *side* of an aisle was given a number and called a *face*. Each building was given a number followed by a number showing the floor. The bays along a face are also numbered from one end of the building. The result is that by a series of three numbers, separated by hyphens, the exact location of any item on any floor of any building can be found. For example 11-3-13 would designate the first floor of building 1, third face, 13th bay from the end. Each item space has a sign suspended from the ceiling over it showing its face and item number. It is not necessary to repeat the building and floor number on each sign as the operators quickly learn them.

MATERIAL HANDLING

While there are several types and makes of fork trucks used in the mill the ones that are essential to our packing, warehousing and shipping operations are the walkie electric fork truck and the electric stand-up rider fork truck.

The walkie trucks are used at the end of the carton packing and sealing lines by the operators of the carton sealing machine. They place an empty pallet on the floor which is loaded with cartons as fast as they are sealed. When a full load is completed the sealer operators use the fork walkie to move the load a few feet to place it on the main aisle where it is deposited to be picked up by a warehouse trucker.

The stand-up rider-type trucks were selected for the greatest efficiency in picking up orders. Many shipments require just a few cartons of many different grades, weights, colors, and sizes. As each carton weighs about 130 lb. it requires two men to pick up a carton from its storage space and put it on the pick-up pallet on a fork truck. Ease and speed of getting off and on the truck were essential. It was found that the stand-up rider truck was far more efficient than the sit-down rider-type for this service. They were also more flexible and easier handling and the men like the trucks for this work.

Sit-down rider-type trucks are used elsewhere in the mill for services where it is not required for the operator to get off and on frequently.

The automatic hoist is the heart of the warehouse and takes loaded pallets down and brings stacks of empties up with no further attention than putting loads onto the feed-in conveyors and removing them from the discharge conveyors. The vertical diagram of the hoist will help to make the following description more clear (see Figs. 4 and 5).

The hoist and its feed and discharge conveyors are operated by six electric motors, all equipped with automatic brakes. Four motors drive the four floor

Fig. 2. Truck doors

conveyors, one motor operates the short conveyor on the hoist floor, and the remaining motor on the head rig moves the hoist up and down. There are 16 photoelectric units and four limit switches to operate the hoist and provide the necessary safety features. The arrangement of light beams and relays is such that failure of a light bulb or photocell stops action of the particular part of the equipment that it controls. This eliminates risk from this source. Each horizontal

conveyor has a light beam along its entire length on the loading side. When any one of these beams are interrupted it immediately stops the movement of that particular conveyor so that a truck can put on or take off a load with perfect freedom at any time. There are two limit switches at the top of the hoist travel and two at the bottom. The first switch in each case is to stop the hoist conveyor in line with the conveyors on that floor. The second switch is for safety to cut the circuit to the hoist motor in case of failure of the first switch. There is a light beam across the ends of the two receiving conveyors which stops the motion of the entire equipment when the conveyor is filled up with loads and can run no further without dumping a pallet off the end.

In operation the sequence is as follows: when the current is turned on the lights to the photocells light up and the receiving conveyor A starts to run and continues to do so until a truck approaches to put a load on it. As soon as the load is on and the truck has left, the conveyor starts and moves the load up to the entrance to the hoist where it interrupts a beam that stops that conveyor and starts the motor on the head rig to bring the hoist into place to receive the load. When the hoist is in place both the feed in conveyor and the hoist floor conveyor start and transfer the load onto the hoist where a light beam at the further side stops the hoist conveyor B from going too far. Another beam at the input side prevents the hoist from going

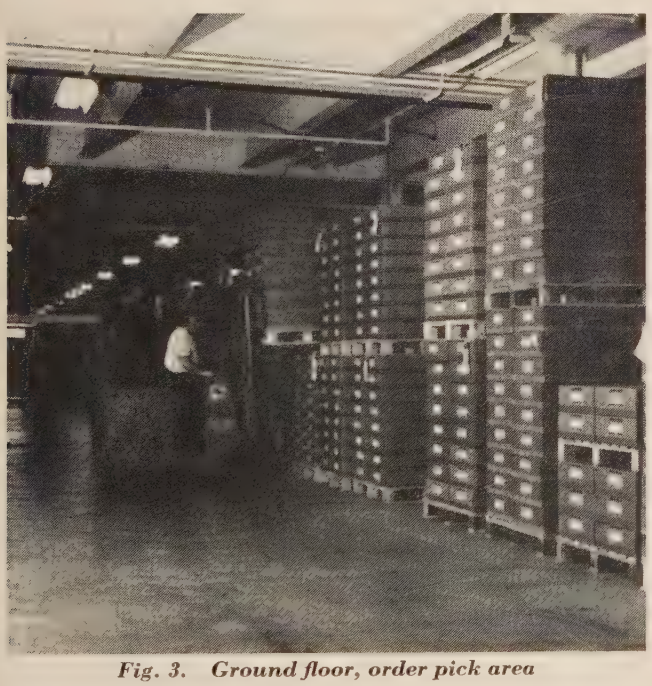

Fig. 3. Ground floor, order pick area

down until the beam is clear or "made." Thus a load must be fairly on the hoist and not protrude at either end for the hoist to be able to move.

As soon as the hoist is properly loaded it descends to the ground floor where it is stopped flush with the receiving conveyor by a limit switch. The hoist conveyor B and the receiving conveyor E start simultaneously and the load is moved out onto conveyor E where a beam stops it as soon as it has cleared the hoist.

While the hoist was going down the feed in second floor, conveyor A has started and brought the next load to position to go down. As soon as the hoist has discharged its load it goes up, takes on the next load, descends, and discharges it onto the receiving conveyor

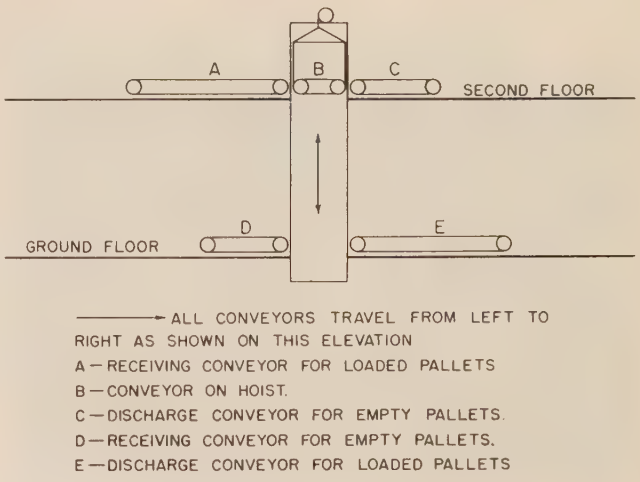

Fig. 4. Vertical diagram of automatic hoist with accessory conveyors

E which moves along one paliet position. This action will proceed indefinitely as long as loads are put on and taken off or until the master switch is changed from "down" position to "up".

When this is done this makes the conveyor D on the ground floor the input conveyor, and conveyor C on the second floor the receiving conveyor. The action is then the reverse of that just described as it consists of taking stacks of empty pallets up and discharging them on the second floor. These conveyors are only half the length of the load conveyors as nowhere near as many up trips are needed as down trips.

CONTROL METHODS

Without going too deeply into details the methods of control will be described.

First, it is emphasized that the warehousing is an entirely separate function from production and comes under a separate superintendent and foreman. Although the finishing and packing operations are on the second floor of the warehouse and the men work side by side, there is a cleavage between the two departments, enough so that they would both function in exactly the same way if they were a hundred miles apart.

When the packing department completes a load of cartons they make out a ticket in triplicate which gives the grade, color, size, basis weight, etc., of the paper and the number of cartons in that particular pallet load. One of the tickets (green) goes with the load, one white ticket goes to the tabulating department as part of the record of that day's production, and the third ticket (goldenrod) stays in the packing department as their record.

The completed load of paper with its descriptive green ticket is placed beside the main aisle and the packing department is then through with it. A warehouse truck picks it up and takes it to the warehouse receiver's station beside the hoist in the center of the

room. The receiver checks the ticket against the contents of the load and if they agree he marks the destination of the load. If the ticket does not agree in every respect with the actual contents of the load he refuses to accept the load and sends it back to the packing department where it has to be put in order before the warehouse will accept it.

Fig. 5. Hoist and feed-in conveyor, second floor

For paper that is going to the ground floor of the warehouse there is no particular problem. The receiver either has the information on hand as to the space available or he can call the ground floor through intercom loud speakers and get information right back as to how much they can take. He then marks the destination on the load, the trucker puts it on the conveyor and that's that.

There are two types of production that are held on the second floor and a record has to be kept as to what, how much and where. These two types are "surge" which is more of any one standard item than there is space for on the ground floor, and "special pack" which is an order made for a definite customer and which is non-standard in some detail and therefore can't be taken from regular stock.

When "surge" loads are put into storage on the second floor the receiver designates where it is to go by a face and bay numeral system modelled on the ground floor but laid out in larger blocks of storage space. In this case, however, he keeps the green ticket which came with the load, marks on it where the load is stored and then files the ticket under a spring clip on a vertical leaf panel board. One panel is used for each grade and only one item is kept under any particular clip. The incoming tickets are put at the bottom of the group in each clip and as paper of that item is removed to replenish pick-up inventory on the first floor, or for full pallet load shipments, the top tickets are taken from under that clip which results in the oldest paper being moved first.

The "special-pack" items are handled practically the same as the surge items and are kept track of by individual tickets except in this case the tickets are filed by customer rather than by grade.

ORDER FILLING, TABULATING, AND SHIPPING

At the same time that the new warehouse was built our tabulating department was enlarged to take care of details of inventory and writing of releases, manifests, and billing. It is now being set up to also take care of the order writing for the mill.

The tabulating department is equipped with "tub" files which are filled with indexed and pre-punched cards for customers, shipping routes, grade, color, size, basis, etc. of paper, standard tare weights of each cartonned item, etc.

With the completion of writing up the orders in this department the functioning will be as follows: an order is received in the order department from the customer. Order department edits it and passes it to the tab department which then pulls cards from the tub files showing customer, routing, and details of items on the order. The machine then prints up the order automatically from these cards. The original customer's order and a copy of the machine printed order are returned to the order department and the tab department files the bundle of cards representing the order.

The next step is when the order department wishes to instruct shipping to ship part or all of this particular order. To do this they write up a "release" showing the items to be shipped from that order and send a copy to traffic which puts on release numbers, shipping route rates, etc. and then returns it to order department which passes it to tabulating.

Tabulating takes the bundle of punched cards representing the entire order and pulls the cards representing the items to be shipped and puts them in the machine while the remaining cards are put back in the file. The machine then prints up the information from the cards onto a "get-out" sheet showing customer, release number, items, quantities of each item, it extends the total weight of each item and prints the location in the warehouse where that item is to be found. Five copies of this sheet are automatically printed by the machine.

Several copies are used for getting out the items for that shipment. They go to the shipping office where a shipping space is assigned to accumulate the items for loading. The foreman gives one or more copies to a pick-up crew and another to a checker who checks off the items on his copy as they are brought in by the crew. Another copy is used later by the loader who checks the items as they are put into the carrier. Between the pick-up crew's copy, the checker's copy and the loader's copy a triple check on possible errors is obtained.

These papers all go back to the tabulating department which now uses the same punched cards that were used to write the orders and manifests to make out the bills, calculate the weights, add prices and make the extensions, and calculate and print the freight on the bills. These latter details, which do not appear on the earlier sheets, are obtained by inserting properly punched cards in the same pack which was used in the previous operations.

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A Study of Moisture Content of Paperboard

WALTON HANCOCK and SAMUEL L. GOLDHEIM

The importance of controlled moisture content in paperboard for converters such as manufacturers of folding boxes is indicated briefly. An investigation at Lord Baltimore Press resulted in: (1) selection of an instrument for measuring moisture content, (2) determination of equilibrium moisture content for 48% R.H., 75°F. conditions, (3) study of more than 1000 skids of board as received. The results of this study indicated unexpected variations of moisture content not only from lot to lot, but also within a lot and even from sheet to sheet. Moisture contents from 3.5 to 10.5% were found and less than 75% of the skids tested fell within reasonable limits of moisture. Analysis of the results showed that the key factors in the variation were: the mill, the type of board, and the sequence of manufacture. With such data at hand, collaboration with the mills produced a marked improvement in their shipments. Much remains to be done on this problem, but better control will benefit both mill and converter.

THE variations of moisture content in paperboard with consequent lack of equilibrium with pressroom atmosphere are known to be the cause of some troubles and suspected of being the cause of others. Thus, stretch and shrinkage of board during processing can be definitely traced to low and high moisture content, respectively. Much less well understood is the effect of variable moisture content on ink receptivity, on ink drying, on mechanical press handling, on final color, and on bender qualities.

The magnitude of the problem is indicated by the measures which Lord Baltimore Press has taken for some years: first, the air conditioning of the entire plant from receiving room to shipping; second, the preconditioning of entire lots of stock to equilibrium with plant atmosphere.

Very much less data are to be found in the literature on moisture in paperboard than on paper. The lack of concrete facts led the management of Lord Baltimore Press in September, 1952, to institute a forward-looking program designed to obtain firm information on this pressing and puzzling problem in the folding box field.

As a high quality converter, Lord Baltimore Press was faced with the universal problem of the ever ascending spiral of quality—as the customer demands higher quality, the converter must in turn require higher quality from his suppliers. Merely requiring "quality" as an abstract idea, however, is not enough; the facts must be pinned down.

In the present case of moisture content of board, the plan of attack on the problem followed the following pattern: (1) selection of an instrument to measure moisture content in paperboard, (2) determination of equilibrium moisture content for the conditions at Lord Baltimore Press, (3) study of the moisture content of incoming stock as received, (4) analysis of the results, and (5) collaboration with the suppliers to eliminate the variability of moisture in the paperboard.

The oven drying of board samples is still the industry standard for determination of moisture. It presents numerous disadvantages, however, since it is time-consuming; it requires that the skid of board be unbanded, unwrapped and sheets removed; it is almost impossible to prevent change in moisture in the sample during sampling and before laboratory weighing.

Accelerated drying of a weighed sample at high temperatures in forced draft reduces the time of analysis but fails to eliminate the other objections above.

The LTF or Cambridge "swords," while very useful for pressroom checks, do not permit accurate enough results and, in any case, still require that a skid of stock be unbanded and unwrapped before test. Not only does this permit change of moisture before and during the test, but also introduces a hazard in the tiering and handling of unbanded skids as well as inconvenience in floor area utilization in a busy plant.

Instruments are available for connection to electrodes which have been sealed into the skid. This is expensive and presents a hazard in that the metal electrodes could be overlooked and might damage a press.

Other instruments are available for indicating moisture by contact with the board. These, however, can only be used on the top of the skid and their response is limited to the top inch of board.

Moisture sensitive color indicator cards have been developed, but are difficult to read and of low degree of accuracy.

The instrument finally adopted for this work was a modified Hart moisture meter (manufactured by Raymond S. Hart, Inc., Grand Central Terminal, New York, N. Y.). This has been accepted by a number of mills and in our study we found it useful. As usually used, a sample of board is clamped between two fixed area electrodes and the conductivity determined by a null point bridge method. The conductivity is related to the moisture content of the board and by previously calibrating the instrument to the particular type of board being tested by means of an oven drying, moisture reading may be obtained in less than a minute. Two polished metal "knives" furnished by the manufacturer may be substituted for the fixed electrode clamp as follows: without unbanding or unwrapping the skid, cut a small flap (say 6 by 6 in.) in the wrapping; insert the knives at about a 90° angle to each other with one sheet of board between them in such a way that the blades cross about 4 in. in from the edge of the skid; rest the instrument electrodes on the protruding knife handles and read in the usual way; remove the knives; close and tape the flap if desired. In this way, the weight of stock and pressure of the banding on the crossed knives separated by one sheet reproduces the effect of the electrode clamps. Some "elbow grease" is

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required to force the knives into the skid but with practice, four different places may be tested on one skid in about 10 min. It is difficult to avoid marring the sheet or nicking the edges with the knives and it is our practice to mark with crayon each place tested so that the pressman will exercise particular care at such points.

Extensive tests have indicated that the Hart meter, when used as described, has a reproducibility of 0.2% moisture content and an accuracy (on the average of two to four tests) of 0.5% moisture content, based on oven drying as a standard. Variations in caliper do not affect the readings, but type of stock does and frequent recalibration is desirable. The instrument is reasonably rugged, but shielding was found important and loose connections gave some trouble. When using the knives instead of the fixed electrodes, a minimum pressure must be exerted on the knives to obtain a true reading. For this reason, the knives are used on banded skids only.

Concurrent with our search for an instrument to measure moisture content, experiments were made to determine what moisture content of board represented equilibrium conditions with the air-conditioned atmosphere at Lord Baltimore Press. Complete air conditioning throughout the plant provides 24 hr. a day, year-round control at 75 ± 1°F. and 48% ± 2½% R.H.

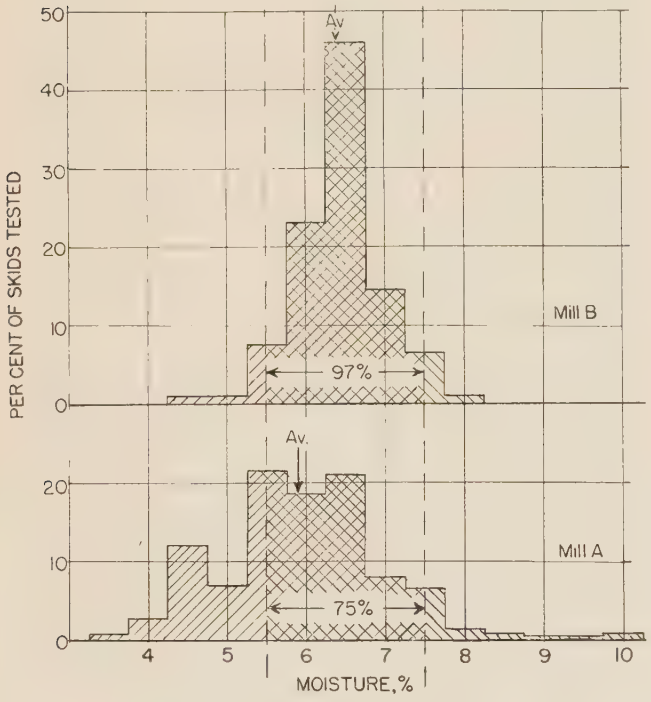

Fig. 1A. Comparison of moisture distribution in lots of machine coated news back paperboard from suppliers A and B. Sample size in both cases greater than 100

In this case, time permitted exposure of samples for long periods and the very simple procedure was adopted of exposing 12 by 12 in. squares of board placed in a rack to permit free circulation of air. Moisture content was then determined after exposures of 3 to 8 weeks.

In all cases, the moisture content of board in equilibrium with 75°F. 48% R.H. was found to lie between 6.0 and 7.0%. Based on these data, a *tentative* specification was set up for 6.5% moisture content for all boards with a permissible range of 5.5 to 7.5% for incoming stock. It is quite possible that continuing studies may require modification of this tentative specification—particularly for litho work where stock seems to process better when on the high side of equilibrium.

Armed with the above data, we were now prepared to make extensive tests of incoming stock as received.

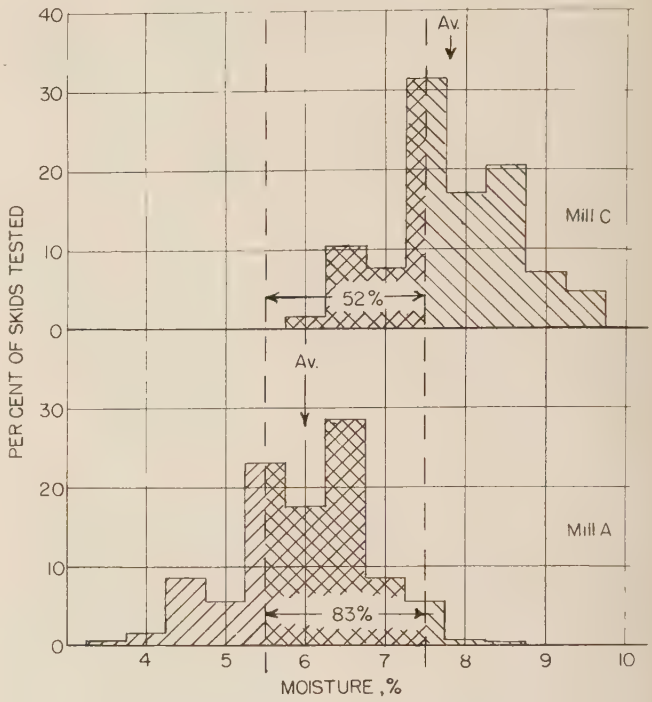

Fig. 1B. Comparison of moisture distribution in lots of clay coated news back paperboard from suppliers A and C. Sample size in both cases greater than 100

Arrangements were made to have the mills mark each skid on the outside with the lot number, type, and skid number. With cooperation between the receiving department and the laboratory, arrangements were made to test skids within (at most) a few hours of arrival and in any case before unbanding and unwrapping.

Initially tests were made in two places on each skid; later experiments were made in up to 12 tests per skid. Very little difference in data showed up as the number of tests per skid was increased and four tests per skid are now considered most satisfactory. Except in unusual circumstances, the individual readings on each skid were averaged. Tests of the upper one eighth and lower one eighth of a skid were avoided because of the possible effect of wet wooden pallets or other extraneous influences.

Some questions of the effect of temperature on the readings with the Hart meter were raised during winter and summer months. It was found, however, that no serious temperature effect was involved—the temperature coefficient of the Hart meter is about 0.3% moisture content for 10°F. Coupled with the fact that most of the stock in this study was in transit only a short time, this low temperature coefficient was ignored.

Incidentally, some healthy skepticism in the pressrooms as to the reliability of the new type of testing was

soon dispelled when it was found that the Hart meter readings agreed well with the LTF sword and correlated well with pressroom experience.

ANALYSIS OF THE RESULTS

In the first 3-month period, about 1000 skids of paperboard were tested. The results were analyzed by: (1) manufacturer, (2) type of board, (3) sequence of

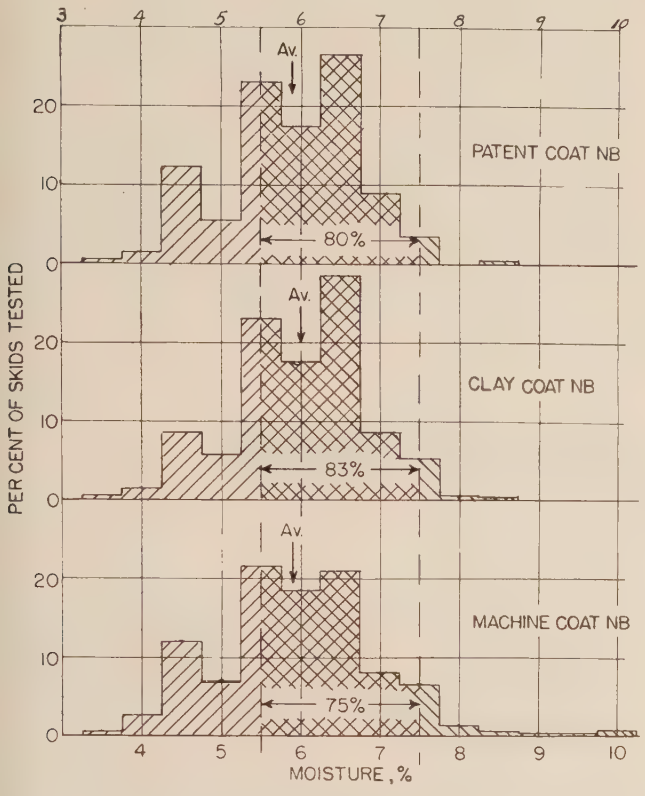

Fig. 2. Comparison of moisture distribution in lots of paperboard of various types from supplier A. Sample in each case greater than 300. Types: patent coated news back, clay coated news back, machine coated news back

manufacture (at the mill), (4) caliper of board, (5) use of board (litho or letterpress), and (6) handling of board (trimmed versus untrimmed).

It was immediately clear that only the first three items were important.

The results are presented in accompanying charts. Figures 1A and 1B show a comparison between the same type of board from various mills. Figure 2 shows a comparison between different types of board from a single mill. Figure 3 shows the variation in moisture content of a single lot of stock from skid to skid.

In these charts, the average moisture content of skid has been rounded off to the nearest 0.5%. A study of the range of four readings within a single skid has been made. While it is not within the scope of this article to go into the statistics of the tests, it may be stated that the range of four tests on one skid varied from 0 to 2.0%, but the *average* range was quite constant for several mills and several types—0.5 to 0.6%. No attempt was made to determine whether this represents the inherent variation of the stock or of the testing instrument. It does, however, correspond to approximate 3 sigma limits of ±0.8% which is considered justification for our original specification of ±1% around the average (5.5 to 7.5% moisture content— see above).

A number of surprises came out of these data. For example, moisture variation from 3.0 to 10.0% in incoming stock was noted in some cases. Whole shipments were found excessively wet or dry. Off-machine coated stock was almost always more uniform than machine coated. On one type of machine coated stock, only 75% of the skids received in a 3-month period were within the 5.5 to 7.5% moisture content limits. As a matter of fact, of the first 410 skids of all types and manufacture of board which were tested, only 70% were within our tentative specification limits.

The most disturbing fact which derived from these early data was the lack of uniformity in moisture content. It is clear that if a lot of stock were uniformly dry or uniformly wet, it could be handled fairly well on a press by appropriate mechanical corrections. When the stock varies from skid to skid—or, even worse, from sheet to sheet—correction becomes impossible.

When data had been collected on about 1000 skids, it was felt that a sufficient pattern had been established to warrant taking the facts to our suppliers—the mills.

Representatives of the mills concerned were invited to our plant (at different times, of course) and given the factual data as outlined above. In each case, the mill was shown the data for its own stock, but given all other data only in a coded chart. An honest effort was made to preserve the identity of competitive data and to avoid both threats and the appearance of "playing" one supplier against the other.

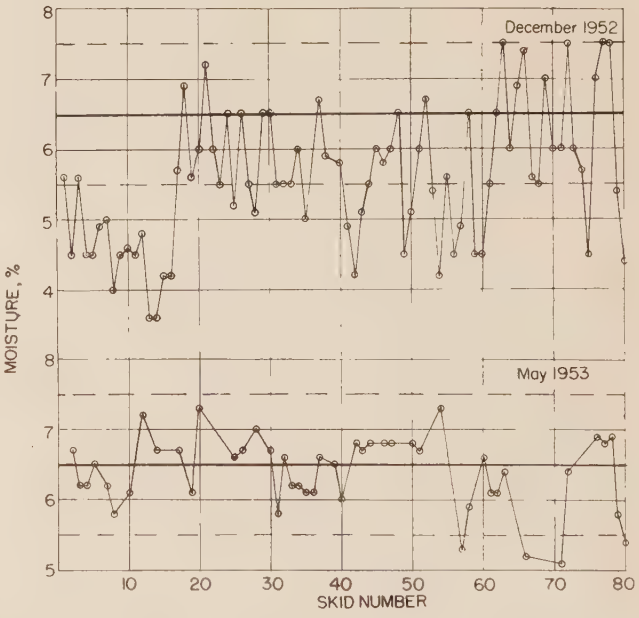

Fig. 3. Variation of moisture from skid to skid within a single lot of machine coated news back paperboard from supplier A. Comparison between a lot in December 1952 when the study was started and a lot in May 1953. Each point represents the average of four readings on one skid

To us it seems obvious that it is to the distinct advantage of the mill to meet these quality problems without flinching—we are happy to report that almost without exception our suppliers took the problem in stride and made honest efforts to solve it.

Just how the program has succeeded is perhaps best illustrated in the following summary for mill A, machine coated newsback.

Date	No. of skids tested	Average moisture content of all skids tested, %	Per cent of skids tested within tentative spec. limits 5.5–7.5%
Oct.-Nov. 1952	197	6.3	75
Dec. 1952	348	5.6	74
Jan.-Feb. 1953	190	5.7	75
Apr.-May 1953	287	6.4	92
June 1953	115	6.5	92
July-Aug. 1953	38	6.1	92

Figure 3 also shows the type of improvement found within a single lot by comparing the skid-to-skid variation of a lot received in December, 1952, and one received in May, 1953.

To indicate that the problem has been completely solved would, of course, be foolish. For one thing, there are two general methods by which the mills can hold moisture specifications to customer requirements: (1) by producing board to close moisture tolerance, and (2) by inspecting and culling out of shipments those skids which fail to meet specifications.

Needless to say, the first method is far more desirable from the standpoints of both the mill and the printer. Until the mills can control the moisture of their boards off the machines, variations will still be a problem.

Lord Baltimore Press still finds it necessary to condition far more stock than it would like. It has been possible by means of this testing program to reduce the load on the conditioners—in many cases, it is sufficient to condition only those skids within a lot which test too dry or too wet. However, the cost of conditioning any stock, the delay in production, and the strain or deformation produced in board by hanging are objectionable features to a busy converter.

It is to be hoped that board mills will see the advantages to themselves as well as to their customers in closer control of moisture content. The advent of the day when a converter can order and receive 99% of his stock within, say, $\pm 1/2\%$ of the equilibrium value for his plant, will see a day in which many of his most vexing problems will be eliminated.

Received July 14, 1954.

Color Removal from Kraft Mill Effluent

W. A. MOGGIO

Laboratory studies directed toward the removal of color from kraft mill effluent indicate the feasibility of using hydrated lime followed by the recovery of the lime from the resulting precipitate by calcining. Major obstacle in the recovery of the lime is the handling and dewatering of the hydrous sludges formed. Treatment of these sludges by carbonation and further treatment of carbonated sludges with spent kraft cooking liquor (black liquor) offers a promising method for the economical recovery of the lime in the sludges.

The significance of color in kraft mill effluents has increased greatly in recent years due to the increased emphasis on stream pollution abatement. Progress toward the solution of the problem of color removal from kraft mill effluents has not kept pace with the progress made toward the solution of the biological stabilization problem of these effluents. This lag is attributable to the fact that the latter problem was considerably more pressing from a pollution abatement standpoint. Inasmuch as the substances which impart the color to the kraft effluents exert little or no biological oxygen demand the problem of their removal did not enter into the kraft effluent biological stabilization problem.

In spite of the fact that color, *per se*, creates no stream pollution problem in the usual meaning of the term, extensive research has been undertaken to solve the problem of color removal. The removal of color from kraft effluents is of importance primarily because the presence of the color in streams receiving the effluent is prima-facie evidence to the public that the stream contains kraft mill effluent. This usually results in accusations and allegations of stream pollution which are frequently unwarranted and unjust. In some cases, however, the presence in a stream of color having its origin in a kraft mill effluent may have pollutional significance. This is in the case where the stream water may be used as source for a public water supply or industrial supply in which color is undesirable.

This highly diluted color in a stream is easily removed by the usual water treatment methods used for color removal. The nature of the color bodies contained in kraft effluents is very similar to that of the naturally occurring color bodies found in streams which receive drainage from low-lying swampy areas.

The color bodies in kraft effluents are primarily lignin compounds which are formed in the kraft pulping process through the dissolving action of the cooking and bleaching chemicals used in the manufacturing process. Approximately 95% of these dissolved lignin compounds are recovered and burned in the chemical recovery system of the pulping process. The remainder are found in the mill effluents which are discharged. They impart a brown color to the effluents, the intensity of which depends upon such variables as: the source of the effluent, quantity of water used in the manufacturing operation, the efficiency of the chemical recovery system, and whether or not bleaching operations are incorporated in the manufacturing process. Color intensity ranges from 500 to 1000 as measured by the platinum-cobalt standards. A characteristic of kraft effluent color bodies is that they increase in intensity with increasing pH values. At pH values on the acid side they become increasingly insoluble. As previously mentioned, the color bodies exert little or no biochemical oxygen demand.

The removal of color from kraft wastes can be accomplished by either biological, physical, or chemical means (*1*). In the process developed for the

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reduction of kraft effluent B.O.D. by a modified activated sludge treatment it is possible to remove approximately 30% of the color. It may be concluded, therefore, that this method is not suitable for color removal from kraft effluents. Physical methods employing char, clay, or activated carbons are effective in removing up to 95% of the color but the quantities of these materials required are of such magnitude that the costs are all out of reason. As an example, the cost for activated carbon alone, based on 1951 prices, would be $1430 to $1870 per million gal. of kraft effluent treated.

Various chemical treatment methods employing hydrated lime, alum, ferric sulphate, sulphuric acid, ferric chloride, chlorinated copperas, phosphoric acid, waste pickle liquor, and a barium alumina silicate compound have been experimented with and have yielded varying degrees of color removal from kraft effluents. Critical examination of the results (*1*) has shown that in all cases the quantity of chemicals needed to achieve the desired color removals results in costs which are considered economically unsound. Added to the high chemical costs are the costs for equipment, operation, and maintenance, which must also be considered. In addition to the problem of costs certain technical aspects further complicate the situation. Of greatest significance are the tremendous quantities of sludge which result from chemical treatment of the effluents, which are a common drawback to the chemical treatment of any waste effluent. These sludges are generally gelatinous in nature, low in solids content, and extremely resistant to dewatering by any of the presently known and accepted methods of sludge dewatering. In addition to the sludge disposal problem some of the chemicals used would also require corrosion resistant equipment.

The disadvantage of cost for the chemical treatment processes for color removal from kraft effluents is not insurmountable, as it may appear at first glance. Recovery of the color-removal spent chemicals, if it can be done economically, and their re-use in the treatment process will overcome, to a large degree, the disadvantage of high cost. Another possibility is the recovery of the spent chemicals and their conversion to a saleable by-product which will defray all or part of the costs for color removal. In the case of kraft effluents the former procedure appears to offer the

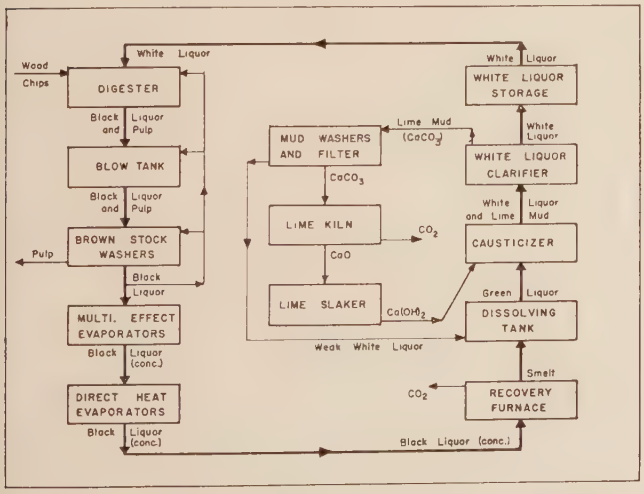

Fig. 1. Kraft pulping process

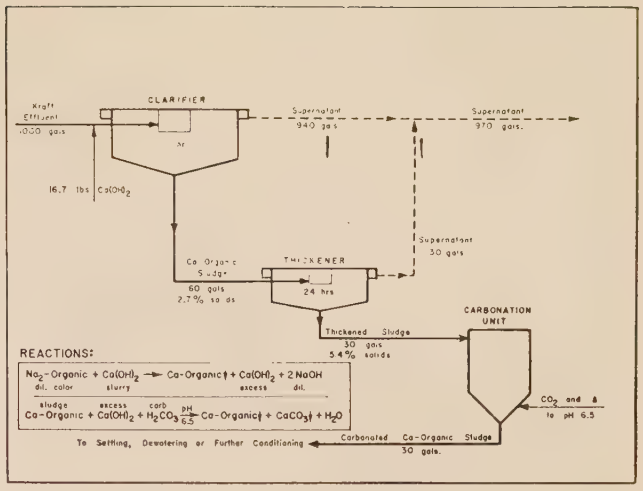

Fig. 2. Treatment of kraft effluent and calcium-organic sludge

greatest possibility of successful application at the present time.

Based on a critical examination of the available data and experimental results it was deduced that, in the case of color removal from kraft effluents, the use of hydrated lime offered the greatest promise of eventual success from economic and operation standpoints. The major technical obstacle to be overcome is the conditioning and dewatering of the hydrous sludge obtained as a result of the color removal treatment and the recovery and eventual re-use of the calcium oxide content of the sludge.

In the course of the extensive laboratory investigations of this problem several chemicals were used, in addition to the hydrated lime, for conditioning the so-called calcium-organic sludges resulting from the hydrated lime treatment of the kraft effluent. Among these are carbon dioxide, sodium carbonate, and sodium hydroxide. In order to utilize these chemicals in the form in which they occur in a kraft pulp mill, the source of carbon dioxide was envisioned as the stack gases from the lime kiln or the spent cooking chemicals recovery furnace. The source of sodium carbonate was envisioned as the kraft "green liquor" or "black liquor" while the source of sodium hydroxide was the kraft "white liquor." In order to facilitate the understanding of the origin of the above chemicals, as well as to indicate how the color removal chemical recovery scheme fits in with the manufacturing operations, reference is made to Fig. 1.

The experimental work reported upon in this presentation represents what appears to offer the best possibility of successful application. Actually, this represents a small part of the overall effort and methods investigated (*2*). Where carbonation is used the source of carbon dioxide, in the case of the laboratory work, is compressed gas although the source of carbon dioxide in any possible future large scale investigations is envisioned as the stack gases from the lime kiln or process chemical recovery furnace. Where black liquor is used the source is the black liquor from a kraft mill. It must be kept in mind throughout the sludge conditioning experiments that the active ingredient of the black liquor is sodium carbonate.

Kraft pulp mill effluents can be treated with hydrated lime for color removal in several different ways.

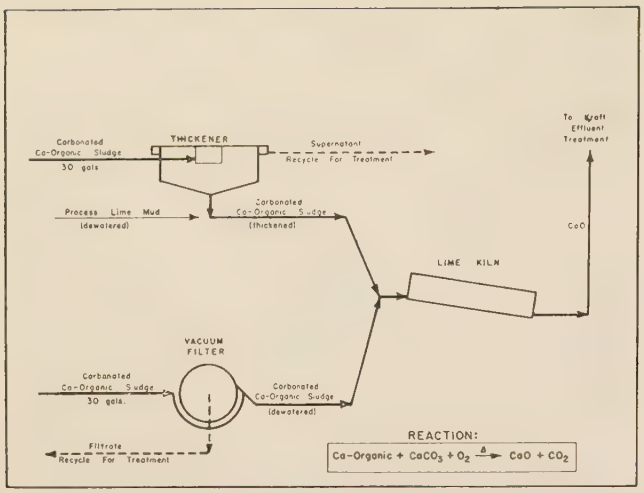

Fig. 3. Thickening, dewatering, and calcining of carbonated calcium-organic sludge

These methods may be classified broadly into single-stage treatment and multiple-stage treatment. After intensive investigations it was determined that the single-state treatment method was unsatisfactory due to certain disadvantages, one of which was the inability to control the reactions so that optimum conditions could be consistently attained (*3*). In spite of the apparent simplicity and lower equipment cost features of the single-stage process it was temporarily shelved in favor of the multiple-stage process investigations. The former, however, possesses certain attractive features which warrant further investigation particularly in light of the knowledge gained from the experimental investigations of the multiple-stage process.

To date, the multiple-stage treatment processes have been narrowed down to two methods which offer the greatest promise. Both of these processes involve the treatment of the calcium-organic sludge obtained from the addition of hydrated lime to the kraft effluent. Both methods involve the carbonation of the sludge and one involves further treatment of the carbonated calcium-organic sludge with black liquor. The aim of both processes is the conditioning of the calcium-organic sludge so that it will lend itself to economical dewatering in standard equipment with the ultimate objective of recovering the calcium content of the sludge in a re-usable form. The reason for attempting to solve the sludge handling problem first is, that in all previous chemical treatment methods for color removal, the matter of sludge handling has always been the insurmountable obstacle. It was felt, therefore, that if the sludge handling problem could

Table I. Settling of Carbonated Calcium-Organic Sludge.[a]

Temp., °C.	Volume, gal. Initial	Settled sludge	Supernatant	Carbonated Ca-organic sludge solids, 1 hr. settling (% by weight)	Weight of dried solids, lb.
50	30	18.3	11.7	8.6	13.1
65	30	17.4	12.6	9.0	13.0
75	30	13.5	16.5	11.5	13.0
90	30	11.4	18.6	11.8	11.3

[a] Based on treatment of 1000 gal. of kraft mill effluent with 16.7 lb. $Ca(OH)_2$.

Table II. Dewatering of Carbonated Calcium-organic Sludge[a]

Temp., °C.	Volume, gal. Initial	Filtrate	Carbonated Ca-organic cake solids % by weight	Weight of dried solids, lb.
50	30	25.5	37.3	13.5
65	30	24.9	42.6	15.1
75	30	25.2	43.2	14.8
90	30	25.5	41.0	13.0

[a] Based on the treatment of 1000 gal. of kraft mill effluent with 16.7 lb. $Ca(OH)_2$.

be solved the solution to the color removal problem would be within reach.

The procedures and data reported subsequently represent only a report of laboratory findings. For the sake of clarity, however, the results are calculated and reported on the basis of 1000 gal. of kraft effluent treated.

The kraft effluent used in the studies was synthetically prepared by diluting some kraft mill black liquor so that its final composition was similar to pulp mill effluent commonly discharged. The calcium-organic sludge used was obtained by treating the synthetic kraft effluent with hydrated lime. The quantity of hydrated lime used was equivalent to 16.7 lb. of $Ca(OH)_2$ per 1000 gal. of kraft effluent. Following the hydrated lime addition the sludge was mixed and then settled for 1 hr. This yielded 60 gal. of sludge with a solids content of 2.7%. Further settling for 24 hr. yielded 30 gal. of sludge with a solids content of 5.4%. This thickened sludge was then carbonated to pH 6.5 and heated to the desired temperature. This much of the sludge treatment is common to both processes. Figure 2 shows a flow diagram of this procedure and the general chemical reactions accompanying it.

Following carbonation of the calcium-organic sludge the sludge can be further handled by sedimentation and thickening or by vacuum filtration, as shown in Fig. 3. The results obtained by this method of sludge handling are summarized in Tables I and II, respectively. The resulting thickened or dewatered sludge may then be calcined in a lime kiln, with the general chemical reaction being shown in Fig. 3. The objective in thickening or dewatering the carbonated calcium-organic sludge is to remove as much water as possible in the most economical way so that the

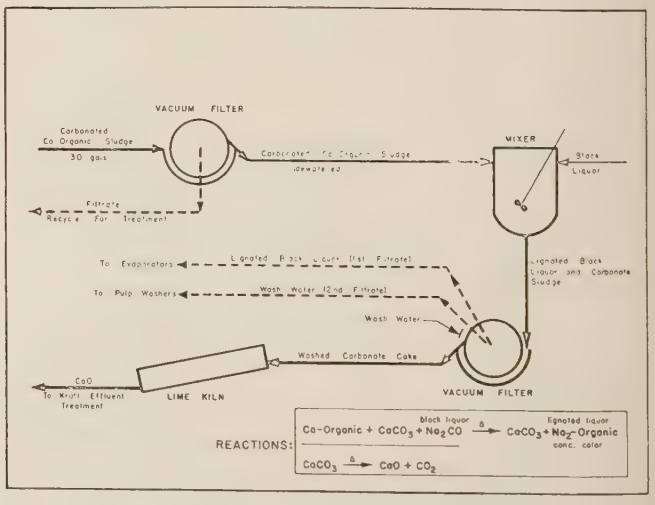

Fig. 4. Black liquor treatment of carbonated calcium-organic sludge

Table III. Black Liquor Treatment of Carbonated Calcium-organic Sludge[a]

Black liquor[b] Solids % by wt.	Black liquor[b] Volume, gal.	Lignated black liquor Solids % by wt.	Lignated black liquor Volume, gal.	Washed carbonate cake solids, % by wt.
15	7.5	14.3	8.1	55.1
	15.0	15.3	16.5	57.1
	30.0	16.3	31.5	60.1
21.8	5.2	19.1	6.3	52.3
	10.3	23.4	10.8	51.9
	20.6	26.6	21.0	52.9
30	3.8	22.2	4.5	54.5
	7.6	29.4	7.8	54.9
	15.2		Filter blinded	
35	1.62	14.5	2.94	46.5
	3.21	20.4	4.50	47.6
	6.42		Filter blinded	

[a] Based on the treatment of 1000 gal. of kraft mill effluent with 16.7 lb. $Ca(OH)_2$.
[b] At 75°C.

calcium oxide content of the sludge may be recovered for re-use.

The data in Table I show the effect of carbonation and heat on the compaction of calcium-organic sludge. A solids concentration of 11.8%, which was the highest obtained, would hardly be suitable for feed to a lime kiln. It may be possible, however, to incorporate this sludge with the manufacturing process lime mud. This would result in lowering the solids content of the process lime mud feed (40 to 60% solids) to the lime kiln but it might be practical if sufficient dewatering and calcining capacity is available. Examination of Table II shows that if the carbonated calcium-organic sludge is dewatered on a vacuum filter it is possible to obtain a cake with almost four times the solids concentration obtainable by the preceding procedure. A cake of 40% solids content is suitable for feed to a lime kiln. Likewise, it may also be possible to incorporate this cake with the process lime mud for dewatering and feed to the lime kiln, if sufficient dewatering and calcining capacity is available.

Another procedure which may be used for conditioning the carbonated calcium-organic sludge is to treat the dewatered sludge with process black liquor followed by further dewatering of the resulting sludge. In this case the filtrate, designated as lignated black liquor, is returned to the process chemical recovery system. The washed carbonate sludge is calcined for the recovery of calcium oxide. The wash water filtrate which will contain diluted black liquor can be returned to the pulp washing system to recover its soda content. This procedure is shown schematically in Fig. 4.

The data in Table III summarize the results obtained by this method of sludge conditioning, using process black liquor of varying solids content. In utilizing process black liquor for sludge conditioning it is imperative, for economic reasons, that the black liquor be recaptured and returned to the process chemical recovery system. For the sake of further economy, since this recaptured black liquor, or lignated liquor, must be evaporated, the increase in volume and decrease in solids content must be kept at a minimum. Examination of Table III shows that it is possible to recapture this lignated liquor with only a small increase in volume while it is actually possible to increase its solids content. The increase in solids content is brought about through the dissolving action of the highly caustic black liquor on the organic matter content of the calcium-organic sludge. The soluble carbonate contained in the black liquor reacts with the calcium of the sludge, forming insoluble calcium carbonate which is filtered out of the resulting mixture. It is noteworthy, too, that the solids content of the washed carbonate cake increases to 50 to 60% as a result of this treatment method, as compared to the preceding methods. Through the use of the black liquor method for sludge conditioning it may even be possible to recover, to a large extent, that portion of the organic matter which is not being recovered presently in the kraft pulp manufacturing process and which has a value as fuel.

The development of a satisfactory and economical method for the handling and disposition of the sludge from the hydrated lime treatment of kraft effluent for color removal does not signify that the complete solution to the color problem has been found. Other facets of the overall color removal problem still require extensive investigation. One of these is the recovery of dissolved calcium hydroxide from the initial supernatant which results from the settling of the hydrated lime treated kraft effluent. Another problem concerns the behavior of carbonated calcium-organic sludges and conditioned carbonated calcium-organic sludges during calcining for recovery of the calcium content. Finally, investigations will be required to determine the feasibility of reusing the treated effluents in the manufacturing process.

In conclusion, the color removal techniques described above possess the following advantages:

1. Hydrated lime is abundant and is the cheapest of the chemicals possessing good color removal properties.
2. Although the hydrated lime dosages are high, as is the case with other chemicals as well, it offers the best recovery and re-use possibilities.
3. The techniques for the recovery and re-use of the calcium content of the sludges are more highly developed than for other chemicals and require no specially designed or fabricated equipment which is not now commercially available.
4. The equipment required for the recovery of reusable calcium compounds from the sludges exists at all kraft pulp mills as part of the manufacturing equipment.
5. Kraft pulp mill personnel possess the background and knowledge required to successfully operate the hydrated lime treatment and recovery processes.
6. The chemicals used in the conditioning of calcium-organic sludges are available at all kraft pulp mills, either as process chemicals or waste materials.
7. The recovery of the treatment chemicals is essentially complete and the treatment process possesses the further advantage that organic matter presently being discharged in the effluents may possibly be recovered.

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The Liquor-to-Wood Ratio as a Variable in Neutral Sulphite Semichemical Pulping

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Several lots of aspen (*Populus tremuloides*) and white oak (*Quercus sp.*) pulpwood differing in initial moisture content were first steamed and then cooked in an experimental tumbling digester by the neutral sulphite semichemical process to compare the effects of liquor-to-wood ratios (by weight) of 5:1 and 2:1. Indirect heating was employed. Only the chemical concentration was varied, in order to keep constant the total amount of chemical applied. Pulps prepared at the lower ratio contained more pentosans and less alpha-cellulose, were obtained in somewhat greater yield, and generally were as bright as or brighter than those made at the higher ratio. Although the differences had research significance, they were probably too small to be of any practical importance Pulp strength, on the other hand, did not vary significantly with variation in the liquor-to-wood ratio. Aspen pulping was not affected by the fact that, at the lower liquor-to-wood ratio, the volume of liquor present was not sufficient to fill the void space in the chips. Furthermore, it was observed that the void spaces in the chips were not completely filled even when the amount of liquor present exceeded the void volume. All evidence pointed to uniform pulping, and presumably uniform penetration, at both high and low ratios of liquor to wood, regardless of chip moisture content before steaming and the temperature schedule used. Although the liquor ratio is not a factor in the semichemical pulping of chips of different sizes, it was noticed that small chips were more completely pulped than larger ones under the same conditions. Equally satisfactory results with the low ratio in a mill-scale operation will depend on satisfactory distribution of heat and cooking chemical.

THE liquor-to-wood ratio is one of the minor variables of the neutral sulphite semichemical process which have not been discussed in print. In a sense, this is a tribute to the well-known ability of this process to turn out a satisfactory pulp under a wide range of conditions. However, this variable has significance in two respects. First, if the waste liquors are to be treated to recover chemicals or to reduce stream pollution, a more concentrated liquor is advantageous, hence, the use of lower liquor-to-wood ratios in the digester is indicated. Second, as the use of semichemical pulps in papers of higher grade increases, the possible small effects of the liquor-to-wood ratio on pulp quality may become of more concern.

Obviously, below certain ratios, the wood charge cannot be completely immersed in liquor. Those chips which must remain above the surface are less favorably situated for thorough impregnation during the early stages; and, as the digestion proceeds, there is limited opportunity for the outward diffusion of reaction products and their replacement with fresh chemical. In the absence of experimental data, it should be assumed that if digestions are made at progressively lower levels, a point will probably be reached beyond which the cooking can no longer be uniform. It must also be recognized that the liquor ratio is not an independent variable. In order to have sufficient pulping reagent present for cooking, the concentration of the chemicals must be increased as the volume of liquid is reduced. Thus, on the basis of accepted chemical principles, changes are possible in both the velocity of cooking and the relative attack on the individual constituents of the wood.

Such effects have been encountered in pulping by the older methods. In cooking by the acid sulphite process, ample liquor is considered necessary during the first stages in order to insure thorough penetration early in the process. Otherwise, the centers of the chips may darken, screened yield will be reduced, and the pulp will show conspicuous shives. With the adoption of forced circulation, it was learned that cooking could be completed satisfactorily if the chips were merely kept wet. Reports of satisfactory operation at ratios of 4:1 and 3.5:1 have been made (*1*, *5*), while the patent literature mentions a liquor-to-wood ratio of 2.5:1 (*8*).

In the alkaline processes, where the black liquor is evaporated and burned to recover the chemicals, from 90 to 230 cu. ft. of liquor are used per ton of air-dry pulp (*10*). Nonuniformity of pulping is recognized as a limiting factor. Because of the preference for the higher end of the range for producing a good grade of bleachable pulp, it must be concluded that a product of best quality is not obtained with minimum amounts of liquor (*8*, *11*). A range of $4^1/_2$:1 to 6:1 for soda pulping and a normal approaching 4:1 for kraft have been cited (*2*).

When strongly alkaline chemicals are dissolved in smaller amounts of water, the rate of cooking is increased. This may be accompanied by a greater loss of carbohydrate substance (*3*, *6*), and the yield of pulp of a given bleachability is decreased accordingly. Secondary effects, such as an increased power requirement for processing, can be expected to accompany removal of pentosans and other hemicelluloses (*12*). Such results, however, should be considerably less in neutral sulphite pulping, inasmuch as solutions of sodium sulphite containing small amounts of buffering agent form a relatively mild cooking medium that is neither acid nor strongly alkaline and that reacts more slowly.

EXPERIMENTAL METHOD

The investigation as planned consisted essentially of cooking the wood at liquor-to-wood ratios (by weight)

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Table I. Cooking Conditions Held Constant Within Series[a]

	Series I (aspen)	*Series II (aspen)*	*Series III (aspen)*	*Series IV, V, and VI (oak)*	*Series VII (oak)*	*Series VIII (oak)*
Chips presteamed in digester, hr.	0.5	0.5	0.5	0.5	0.5	0 5
Sodium sulphite applied, lb. per 100 lb. wood	14.7	16.1	9.2	14.3	8.1	13.8
Sodium bicarbonate applied, lb. per 100 lb. wood	6.0	6.2	6.1	6.1	6.6	5.9
Time to maximum temperature, hr., min.	2:30	2:30	1:15	2:30	1:15	2:30
Maximum temperature, °C.	170	170	160	170	160	170
Time at maximum temperature, hr., min.	1:15	1:45	0:20	1:45	0:10	1:45
Approximate yield, %	76	76	85	71	85	71

[a] Material for each series was drawn from one of two lots of aspen or one of two lots of oak. Minor changes in the cooking conditions were made between series to correct for minor variations in the pulping characteristics between the two lots of each wood.

of 5:1 and 2:1 (including the moisture in the steamed chips, and using indirect heating to avoid dilution) and comparing the products for yield, uniformity of cooking, brightness, strength, and chemical composition. Except for the liquor concentration, which was, by necessity, increased when the liquor ratio was lowered, all variables were held constant within each group of digestions.

It was expected that absorption of chemical would be in a critical stage at the 2:1 ratio. Since the absorption can be limited by factors other than the opportunity for contact with the cooking liquor, brief attention was given to the variables of species and initial moisture content of the wood, as well as to the cooking schedule.

Aspen and white oak were selected as two contrastable hardwoods. Aspen is typical of a lightweight, readily penetrated species with a relatively large void space for the absorption and retention of cooking liquor. White oak, a representative of the heavier hardwoods, was selected largely because of a quality that makes it superior for tight cooperage—low permeability—although the relationship between permeability of wood and ease of penetration by the liquor in cooking has not been established. An examination of the cooked oak chips showed that the tyloses, which are believed to contribute considerably to the impermeability of this species, had not been removed, but it was not determined whether the vessels were still sealed effectively.

The other secondary variables were covered as follows: series I and III (Tables I and II) made use of aspen chips that had previously been air dried, whereas the wood in series II was only partially seasoned. The time to cooking temperature was halved in series III and the period at maximum reduced about 80% for a total cooking time of 95 min. after addition of the cooking liquor. This was believed to be as short a schedule as is likely to be used in pulping by a batch process.

The range in initial dryness of the white oak wood was greater, varying from 50 to 94%. Series IV, V, and VI represent air-dry, partially dried, and green chips, respectively. Chips containing the intermediate amount of water were also utilized in series VII, in which the cooking schedule was again curtailed, with the temperature-rise period cut in half and the time at maximum decreased to 10 min. The total cooking time in this series was 85 min., including the temperature-rise period.

Where the cooking time was cut back (series III and VII, Table I), the quantity of chemical was also reduced and the maximum temperature lowered 10°. Yields accordingly were close to 85%.

A practical measure of the results of reducing the volume of liquor is afforded by comparing the over-all properties of the pulps cooked at the two ratios. It seemed advisable, however, to supplement this with a more direct and sensitive means of detecting nonuniform cooking.

This was done by placing a small basket filled with chips at the axis of revolution of the digester at the time of charging. At the low liquor ratio, these chips would not be submerged at any time. It was postulated that, if the lignin content of the chips in the basket did not change when the liquor ratio was reduced, this would be evidence of the fact that the chips were uniformly cooked even though they were above the liquor level.

A similar basket was filled with equal parts of sawed chips that had been cut to two sizes, one of which was considerably smaller than regular chips and the other larger. Again it was assumed that, if the lignin content remained unchanged, the conditions for satisfactory impregnation and cooking would still be adequate. Due to space limitations, this basket had to be placed just above the bottom cone, where, at low ratio, it would be out of the liquor most of the time.

DIGESTION PROCEDURE

Normal chips, cut $^5/_8$ in. long with a 47-in., two-knife chipper of conventional design, served for the main charge and for use in the basket placed at the axis. The specially prepared large and small chips used to fill the other basket were split from disks cut from a log reasonably free from knots, decay, and abnormal wood. Since the baskets were small—8 in. long and $2^1/_2$ in. in diameter—few large chips could be used. Consequently, unusual care had to be taken that the material would be comparable as to summerwood, growth rate, and so forth. Disks for the small chips were accordingly taken from both sides of and immediately adjacent to the disk cut for the larger chips. Each set of disks was then split into strips of the proper thickness in paper cutter of the guillotine type. The oak sapwood was trimmed from the disks and discarded because it differed so greatly from the heartwood. The short chips were $^3/_8$ in. long by $^1/_8$ in. thick. The longer ones were cut $^7/_8$ in. long by $^1/_4$ in. thick in series I, II, III, and V; and $^3/_4$ by $^3/_{16}$ in. in series IV and VI.

The two tumbling digesters consisted of a steam-jacketed cylindrical main body below which was a conical bottom. Except for the final series of digestions, the cooking was done in a vessel of 0.8-cu. ft. capacity. In this last series, where the larger 13-cu. ft. digester was made use of, the basket placed at the axis was large enough to furnish pulp for a beater test and full chemi-

cal analyses. Rates of tumbling for the two digesters were 1.0 and 0.2 r.p.m., respectively.

The chips were steamed at atmospheric pressure for $^1/_2$ hr. with the condensate draining freely. Because of the moisture introduced by this presteaming, the liquor subsequently charged was admitted in the proportion of either 48 or 12 gal. per 100 lb. of wood (moisture-free basis), which was equivalent to a 4:1 or a 1:1 liquor-to-wood ratio, respectively. The digester was sealed immediately at the end of the steaming period and the cold liquor piped in with the expectation that impregnation would be aided by the partial vacuum formed by condensation of the residual steam.

With indirect heating, a straight-line rise was followed to maximum temperature and the cooking continued for the length of time that would give a concentration of 10 grams per liter of sodium sulphite in the spent liquor at a 5:1 ratio. The cooking schedule and other conditions were identical within each series (Table I). At the end of the digestion, the free liquor was drawn off through a cooler to avoid flashing and weighed up with the softened chips in order to confirm the liquor-to-wood ratio. The digester was not relieved during the cooking.

A small attrition mill reduced the cooked chips to a pulp which could be evaluated by the standard TAPPI methods. The contents of the baskets and a sample of the main charge were put through an 8-cut flat screen after fiberizing and the lignin determined according to the method of Noll (*7*). Although this simplified method does not always correlate with the standard TAPPI method for lignin, it was believed to be satisfactory for evaluating differences in the degree of cooking between various parts of the same digestion.

DISCUSSION OF RESULTS

Effect on Pulp Yield

Reducing the liquor-to-wood ratio, with conditions of time, temperature, and amount of chemical held constant, afforded a slightly greater yield of pulp. In Table III, the yield at the 2:1 ratio is consistently higher for a constant cooking time, although the increase is slight. Changes in the rate of heat transfer when the liquor level was changed, and in the opportunity for diffusion, as well as in the concentration of chemicals, contribute to establishment of the over-all rate of cooking. The effect of the higher concentration at the lower liquor ratio is believed to be small, since general experience in pulping at a constant liquor ratio has shown that an increase in the amount of chemical has little effect in reducing the yield of semichemcial pulps unless the cooking time is increased. According to analyses of the spent liquors, approximately equal amounts of sodium sulphite were consumed.

Liquor Level in Digester

The level of liquor in a digester can vary considerably for a given liquor-to-wood ratio, depending on the species and how well the chips are packed. Differences

Table II. Physical and Mechanical Properties of the Semichemical Pulps Cooked at Different Liquor-to-Wood Ratios

Liquor-to-wood ratio,[a] lb. water per lb. wood	*Initial concentration of Na_2SO_3 in digester, g./l.*	*Brightness, %*	*Beating time,[b] min.*	*Bursting strength, pt./lb./rm.[c] Freeness 500 ml.*	*250 ml.*	*Tearing strength, g./lb./rm. Freeness 500 ml.*	*250 ml.*	*Breaking length, meters Freeness 500 ml.*	*250 ml.*	*Folding endurance, double folds Freeness 500 ml.*	*250 ml.*	*Density, g./cc. Freeness 500 ml.*	*250 ml.*
Series I: Aspen Chips, 94% Dry													
5:1	29.4	52.5	21	0.63	0.88	0.86	0.63	6500	8000	40	250	0.63	0.76
3:1	49.0	55.2	20	0.64	0.85	0.83	0.59	6100	8400	70	220	0.59	0.72
2:1	73.5	55.7	19	0.63	0.88	0.83	0.60	6200	8200	40	220	0.60	0.73
Series II: Aspen Chips, 70% Dry													
5:1	32.2	56.5	20	0.65	0.93	0.91	0.69	6400	8100	54	280	0.73	0.87
2:1	80.5	59.2	18	0.64	0.89	0.90	0.71	6100	8200	30	180	0.72	0.86
Series III: Aspen Chips, 90% Dry, Short Cooking Schedule													
5:1	18.4	48.4	22	0.42	0.64	0.77	0.68	4800	6600	10	48	0.59	0.74
2:1	46.0	47.4	21	0.46	0.67	0.84	0.68	5200	7000	14	67	0.58	0.73
Series IV: White Oak Chips, 92% Dry													
5:1	28.6	26.6	24	0.23	0.42	0.70	0.74	2700	4500	2	9	0.41	0.50
2:1	71.5	26.0	21	0.26	0.44	0.70	0.73	2700	4400	2	10	0 42	0.50
Series V: White Oak Chips, 72% Dry													
5:1	28.6	24.7	23	0.27	0.42	0.69	0.75	2700	4500	2	8	0.44	0.51
2:1	71.5	26.1	22	0.27	0.42	0.68	0.75	2900	4300	1	8	0.43	0 50
Series VI: White Oak Chips, 50% Dry													
5:1	28.6	26.2	19	0.26	0.39	0.66	0.75	2700	4500	2	7	0.43	0.48
2:1	71.5	28.0	18	0.29	0.40	0.67	0.65	2700	4300	3	8	0.43	0.49
Series VII: White Oak Chips, 73% Dry, Short Cooking Schedule													
5:1	16.2	22.9	17	0.06	0.11	0.45	0.53	1000	1750	0	0	0.34	0.39
2:1	40.5	23.6	18	0.08	0.15	0.45	0.53	1200	2000	0	0	0.34	0.41
Series VIII: White Oak Chips, 67% Dry, 13-Cu. Ft. Digester													
Main charge													
4:1	27.6	28.8	18	0.22	0.40	0.62	0.80	2600	4200	2	12	0.42	0.50
2:1	69.0	29.0	18	0.22	0.39	0.65	0.75	2450	4150	2	13	0.41	0.48
Basket charge													
4:1	27.6	28.0	18	0.21	0.40	0.65	0.80	2500	4300	2	12	0.43	0.49
2:1	69.0	26.7	19	0.22	0.41	0.72	0.80	2575	4350	2	13	0.43	0.50

[a] By weight, including the moisture in the presteamed chips.
[b] Time required to reduce freeness from 500 to 250 ml., Canadian Standard freeness.
[c] Ream of 500 sheets, 25 by 40 in.

in wood density alone should make it possible to load within a given space twice as much hard maple as aspen. As a result, the liquor level in the second instance would be considerably lower. Chip packing can raise the level appreciably, but the benefit may be offset by loss in free circulation. A further variation is possible if it can be assumed that the proportion of voids that are filled with cooking liquor is substantially constant for all species. Calculations from apparent specific gravity and density of true wood substance show that 1 lb. of moisture-free aspen can theoretically take up and retain as much as 2.2 lb. of water, whereas white oak can hold a maximum of 1.1 lb. From these figures, the total amount of water present during the cooking of aspen at the 2:1 ratio was theoretically insufficient to fill all the voids in the wood. However, satisfactory cooking apparently took place even though the chips were not completely permeated.

When the free liquor was drained at the end of each digestion for the purpose of checking the liquor-to-wood ratio, it was found that considerably more was recovered than should have been if all the spaces within the wood had remained filled. While this can be explained plausibly on the basis of the drop in pressure during the blowdown, it led to speculation on how quickly and completely the cooking liquor is taken up when the total water present is insufficient to fill all the voids within the chips.

To estimate this, the small digester was packed two-thirds full with chips and the remainder of the space blocked off by means of an empty perforated basket. As the digester tumbled, the effect was equivalent to that obtained by periodically drawing off the free liquor into an empty chamber where the volume could be measured by means of a gage glass without complications due to shifting and settling of the chips.

For air-dried aspen chips, steamed $^1/_2$ hr. using a ratio of 2:1 in cooking, only 35% of the added cooking liquor was absorbed by the end of the first 15 min. and 50% at the end of the first hour (110°C.). The absorption remained close to 75% during the entire time at maximum temperature. These values may vary considerably with the cooking conditions and the design of the digester. Correction was made for the effect of increasing temperature on the volume of liquor, but no other adjustment, such as for increasing solution of the woody substance, was made. An estimate of the percentage of voids that remained unfilled during the digestion is liable to considerable error, since neither the density of the wood nor the amount of moisture introduced in steaming was measured specifically. However, assuming a moisture content of 50% after steaming, and a wood density of 21 lb. per cu. ft. (oven-dry weight, green volume), the chips were only 75 to 80% filled with liquor during the cooking period at 170°C., but cooked normally nevertheless.

Physical Properties of the Pulps

In spite of the small amount of cooking liquor taken up by the chips under some conditions, essentially normal pulps were obtained in terms of strength properties as well as yield (Table II). This was true even in series III and VII, where very short cooking schedules were used. In series VIII, where sufficient chips were available from the axis basket for a separate beater test, it was learned that full strength could be developed even if the entire quantity of chips involved had undergone only incidental contact with the cooking chemicals.

Pulps prepared with the minimum amount of water were appreciably darker in only two instances. In series VIII, a good deal of black iron tannate was formed by the reaction between the wood and the ordinary hardware cloth from which the large basket was fabricated. In series III, the brightness was off by only 1 point.

Table III. Yield and Chemical Analysis of Semichemical Pulps Cooked at Different Liquor-to-Wood Ratios

Liquor-to-wood ratio,[a] *lb. water/ lb. wood*	*Yield, lb./100 lb. wood*	*Lignin, %*	*Holo-cellulose, %*	*Alpha-cellulose, %*	*Pentosans, %*
Series I: Aspen Chips, 94% Dry					
5:1	75.0	12.2	82.1	62.6	17.0
3:1	76.2	12.0	81.4	61.6	17.8
2:1	76.7	13.2	81.1	61.1	18.6
Series II: Aspen Chips, 70% Dry					
5:1	76.3	12.1	83.2	65.4	17.4
2:1	76.7	11.5	83.5	63.8	18.5
Series III: Aspen Chips, 90% Dry, Short Cooking Schedule					
5:1	84.4	17.5	78.4	55.4	18.5
2:1	85.6	18.1	77.3	54.6	18.9
Series IV: White Oak Chips, 92% Dry					
5:1	70.3	16.8	76.7	61.5	18.5
2:1	71.0	16.6	76.1	58.8	19.7
Series V: White Oak Chips, 72% Dry					
5:1	70.1	17.6	76.5	62.1	18.6
2:1	71.4	17.2	75.8	60.3	19.7
Series VI: White Oak Chips, 50% Dry					
5:1	69.8	17.2	76.6	61.0	18.7
2:1	70.6	17.5	76.3	59.7	19.6
Series VII: White Oak Chips, 73% Dry, Short Cooking Schedule					
5:1	84.8	20.8	73.6	53.6	21.0
2:1	84.5	20.4	72.9	53.3	20.9
Series VIII: White Oak Chips, 67% Dry					
Main charge					
4:1	71.5	17.0	77.7	62.3	20.1
2:1	72.1	15.8	77.2	61.2	20.7
Basket charge					
4:1	70.8	16.5	77.2	62.5	20.0
2:1	71.1	15.8	77.3	62.1	20.2

[a] By weight, including the moisture in the presteamed chips.

Small but generally consistent differences were found in the chemical composition of the pulps (Table III). Those cooked at minimum ratio contained slightly less alpha-cellulose. Pentosans, on the other hand, were increased, except in the final series. Inasmuch as the tinniness and low opacity of papers containing neutral sulphite semichemical pulp are attributed to its high hemicellulose content, cooking conditions that cause an increase in this constituent can be considered unfavorable in many applications. A similar increase in the pentosan content of the pulp as the volume of sodium sulphite liquor was reduced has been reported (4) where conditions left no doubt that the material was fully saturated with liquor. An increased content of hemicelluloses is frequently associated with rapid processing. Evidence of this is apparent in the shorter

beating time required to lower the freeness from 500 to 250 ml. (Table II).

Although the differences described may be real, they are small and seem to be of little significance in the preparation of pulps for paper.

Uniformity of Cooking

At the higher liquor-to-wood ratio, the chips in the basket placed at the axis of the digester were submerged in cooking liquor continuously from start to end of the digestion. At the lower ratio, on the other hand, these chips were not immersed at any time, and their only contact with the solution came from whatever trickled over the surface as the digester rotated. If the wood in the basket was inadequately cooked under the latter circumstances, the fact should be indicated by the larger lignin content of the pulp. Also, an increase in loss of carbohydrate would still further increase the proportion of lignin in the cooked chips and be additional evidence of unfavorable cooking conditions in the basket.

No such increases were found, however. In fact, when the lignin content of the basket chips cooked at the high ratio is subtracted from the corresponding figure obtained at the lower ratio in the different series, only one positive value was obtained. The individual differences were as follows:

Series	*Difference in per cent lignin*
I	—0.7
II	+0.2
III	−0.4
IV	−0.2
V	−1.3
VI	−0.6
VIII	−0.3

It is not, of course, acceptable to conclude that chips above the liquor level were cooked more effectively than those which were immersed. It seems more logical to conclude that the small differences are within the range of experimental error and that the lignin content was not appreciably affected. A more comprehensive comparison of the effect of being above and below the liquor level is available in the complete chemical analyses of the basket chips in series VIII (Table III). Here, too, the differences are apparently within experimental error.

Where the cooking conditions are such that there is doubt whether the chips have opportunity for adequate penetration, the size of the chip is a potential variable. This is because larger chips must take up a greater amount of chemical per square inch of surface for an equal absorption in grams of reagent per gram of lignin. In the investigations with combinations of unusually small and large chips, it was found that while the larger sawed chips invariably retained more lignin after cooking, the effect of decreasing the liquor ratio was as likely as not to reduce, instead of increase, the difference. In the tabulation following, the difference in lignin content represents the lignin content of the smaller subtracted from the lignin content of the larger cooked chips.

Again, it may be concluded that the variations resulting from reducing the liquor volume are within experimental error. The 1.3-point increase in the first series appears to be appreciable, but its significance is offset by the facts that only a few of the large chips could be used because of the limited capacity of the basket, so that errors due to variations in the wood could have been greater than usual; and that a similarly large difference was not found in series III where the same materials were used, nor in series IV where air-dry oak was cooked.

Series	*Liquor ratio*	*Difference in per cent lignin content*
I	5:1	0.4
	2:1	1.7
II	5:1	1.0
	2:1	0.7
III	5:1	1.1
	2:1	0.6
IV	5:1	3.8
	2:1	4.4
V	5:1	8.1
	2:1	8.9
VI	5:1	2.8
	2:1	2.0

Examination of the chip centers was not revealing. The white oak specimens were too dark in color to make evident any moderate degree of burning. Brownish centers were frequent among the big aspen chips, but the incidence was about equal at both ratios. Pulps from the large chips were darker in color.

CONCLUSIONS

The liquor-to-wood ratio can be varied over a wide range with only slight modification in the cooking schedule and in the properties of the pulp. The small change in the cellulose-hemicellulose relationship had no effect on the strength of standard test sheets, and very likely would have no effect on papers and boards made from the pulps. It may be concluded that, for present purposes, pulps made at 5:1 and 2:1 liquor ratios appear to be interchangeable. These conclusions, however, are based upon data obtained in experimental equipment. In full-sized digesters heat and liquor distribution and other conditions may exist which prevent uniform cooking in all parts.

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The Use of Statistics for Analysis of Testing Results

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The requirement of precision in a test method is of primary importance from the standpoint of usefulness of results. The peculiar difficulties of measuring precision of pulp and paper tests are pointed out. The most widespread approach is the use of round-robin tests on a homogeneous lot of paper. Some examples of tests of this kind are explained. Several possible ways of using process data to analyze test methods are suggested. Modern statistical techniques have the power to make test methods better understood and to produce information that will make uniformity of performance an attainable goal.

THERE are two main requirements of a good test method, namely that it should be both valid and pertinent. There are other desirable characteristics, such as simplicity, brevity, and economy, but those two are most important from the standpoint of usefulness of the results. To be valid, a method must be both precise and accurate. To be pertinent, it must actually measure the property of interest. Precision refers to the closeness with which the individual test values cluster about their average. Accuracy refers to the bias or the difference between an average value and the "true" or standard value of the measured property. Precision is wholly a statistical problem; accuracy is only partially statistical; and pertinence is even less so. If the true or standard value is known, inaccuracy may be compensated for by calibration of the instrument or adjustment of the data. Pertinence is determined by the correlation of the test results with product performance. The problem of precision must always plague the tester until it is measured and controlled.

PRECISION OF PULP AND PAPER TESTS

Of all these problems, that of precision of the test methods is probably most important to the practical man. The measurement of precision of test methods used to evaluate pulp and paper is a relatively complex statistical task. The material itself is highly variable and it is difficult to separate this material variability from the variability of the measuring instruments. Precision is always related to some particular sampling procedure, to some part of the measurement or manufacturing process, or to the terms of reference of a specification. It involves the combined effect of variability of materials, methods, machines, and men. It is the task of statistics to identify the sources and measure the amounts of the variations in a test method under the particular circumstances in which it is to be used.

The problem of how to sample so as to relate the testing program to the particular questions it is desired to answer is, perhaps, the most difficult one which will be encountered. It is not only a problem of how much testing to do but also of the closeness of samples taken from the paper web and the physical dimensions of the individual test pieces. The small sample statistical techniques now available bring the amount of testing required for any reasonable objective within economic bounds. It is not difficult, with a little background in paper testing, to determine the minimum necessary number of tests. To do this so that all desired groupings of the data result in reliable answers is the job of the industrial statistician. Surprisingly enough, the total amount of testing called for is often less than might be expected. Or, put in another way, when intelligently planned, a program will provide much more information than otherwise, with no more work.

The physical dimension of each test specimen is determined roughly by the instrumentation in many instances. For example, a certain area must be clamped in an instrument such as the Gurley Densometer or a Mullen tester. For basis weight, on the other hand, a specimen of any size might suffice. In measuring caliper, a spot reading might be used or several thicknesses might be measured together. If a complete measure of the variability or contour of the paper is desired for any property, the test piece may be very small. If an average property of the paper, which may be all that is necessary for most end uses, is desired, the dimensions may be relatively large. Too small a sample may introduce certain kinds of measurement errors. For many tests, size is tied in with the calibration or sensitivity of the measuring instrument. The test specimens, whatever their size, must be taken at a distance from one another that is logical for the purpose at hand. There is a minimum distance beyond which it is dangerous to go because of the statistical association or correlation of successive readings that may result. This is a kind of measurement threshold which may provide one of the best means of getting at the ultimate capability of the test. How far apart the specimens are taken depends upon the context within which the test method is to be used.

If the method in which instruments are to be used is standardized and the industry by and large adheres closely to those standards an adequate test program may be set up within the framework specified in the standard. However, in light of the small amount of test method research that has been based on modern statistical methods, no guarantee exists that the standard methods are optimum methods nor even that the instruments are as precise or accurate as they might be.

There are many sources of variability to be considered by the experimenter, in addition to the variability within a paper sheet. There is sometimes a difference in variability of the same grade of paper coming from different machines, or even from the same machine at different times. There is to be expected a difference in the precision of measurements made on different grades and types of paper. Different makes of instruments will differ but even instruments of the same make sometimes vary significantly. The test methods employed from laboratory to laboratory even within the same company may vary. Different interpretation

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of the method, different manipulation of the instruments, and different attitudes cause significant differences among the results obtained by operators. There are blue Mondays, and there is "graphiting," and there is outright duplicity. There is an unconscious preference for certain figures or for rounding off in a certain way and there is a powerful trend for association of results, especially when a specification bound is being approached.

There is often a day-to-day effect due to different equipment set up, calibration, preparation of solutions, or variations in atmospheric conditions. Test specimens may or may not be preconditioned uniformly. Due to these, and other things, laboratories notoriously differ from one another. This sometimes goes to such an extent between customer and supplier that a referee laboratory must be called upon.

Many of these difficulties may be identified and corrected by a well-thought-out analysis of the testing methods. Correction of deficiencies that may exist is a necessary preliminary step to any true evaluation of a testing method as such. Just as a process must be in control in order to produce a product of uniformly high quality, a test method must be in control to produce numbers on which reliable conclusions can be based.

It is important to know how the test results are to be used and whether absolute values or only relative values are expected. It makes a difference whether comparisions are always made with a standard, or among unknown samples: whether comparisons are always within the work of one analyst, or within one lab or within one day. If all the variables mentioned, and possibly many others unmentioned or unknown, can affect the results, they all have to be taken into account in reckoning the precision.

PLANNING A TESTING PROGRAM

The advantages of the statistical approach are lessened unless a fairly complete plan is adopted and carried through faithfully. There should be no missing blocks of data. The number of tests under any given blocking of data should be the same. All individual test results should be reported and only the requested tests should be made. Rules must be established for replacement of lost or ruined specimens and cooperators cautioned against replacing results they just don't happen to like. Provision should be made for uniform recording and summarizing of the data. Uniform rules should apply for number of places reported and for rounding off of figures.

There should probably be a preliminary run as the result of which obvious inconsistencies could be detected and corrected. This would depend on whether there were general willingness to accept things as they turn out knowing that the lack of control seriously affects the confidence that can be placed in results and that every significant source of variation lessens the likelihood for detecting small differences that may nevertheless be important technically. It is the author's opinion that the continuing effort to improve test methods and their use is justified and that a forward looking investigation of testing precision will include a plan for self correction and retesting. As a matter of fact, a well-conceived cooperative plan which will be applied periodically, say at 5-year intervals, could very well be followed by TAPPI.

TESTING OF HOMOGENEOUS MATERIAL

One approach to the analysis of test methods is to use a source of paper believed to be uniform and to mix the test specimens thoroughly to make the selection of samples for any part of the test program as nearly random as possible. Although this doesn't remove the effect of remaining variability in the paper, it does tend to balance its effect by distributing it impartially. If the assumption that the supply of paper is uniform is not true, the apparent precision of the test will be larger than it should be. A knowledge of the source of paper would help in this respect. It is possible that mixing is not the best approach and that a selective or stratified method of selecting samples would be better.

Although this is a popular approach in much interlaboratory testing, it is not at all certain that it is the best approach. This may be because it is not often carried far enough. It becomes very difficult to include all the variables or enough data on some of them. It tends to give results which are better than routine results. No matter how much care is exercised to get ordinary treatment, it is hard to get away from the fact that these are special samples. The results are therefore suspected of bias and sometimes are open to argument. It has been observed that, as a consequence, lengthy programs have been undertaken and even repeated on a regular schedule but that constructive action does not necessarily result. The design should have a clear purpose backed by a firm intention to use the results to control and improve the application of the test method. This applies, of course, to any plan of test that may be devised.

An example of the testing of homogeneous samples of eight grades of paper by each of four operators is given in a case published by Bicking and Trelfa(*1*). A fairly complete description of the method of attack is given there. Some refinements could be made in light of recent knowledge, but the example is still useful and need not be repeated in detail. It will serve as a basis, however, for pointing out that two of the operators showed an inability to check their own work satisfactorily. (Operators B and D had ranges out of control.) Also, the average results obtained by operators B and C checked and those by operators D and A checked but the two groups arrived at significantly different conclusions concerning the water penetration characteristics of the eight papers. These divergent results affect the ability to distinguish between the different papers, which is, of course, the ultimate purpose of the test. This study resulted in the adoption of a technique for more uniform application of sugar dye and a more careful specification of how to determine the end point. The result was improvement in the operator's ability to check their own and other's work and an over-all improvement in the precision of the test.

THE ANALYSIS OF PAPER TESTS

The agreement within and among operators using other testing methods than water penetration was also studied in this program. In general, the same kinds of conclusions apply to basis weight, Gurley Densometer, Valley size, Carson curl, and news ink penetration tests. For all of them, there were inconsistencies in the ability of operators to check their own work or

that of others. From the viewpoint of the reliability of conclusions based on data like these, it is unwise to look upon the results as good measures of the capabilities of the test methods. Regardless of how precise a test method must be for its intended use, the method as performed should exhibit statistical control. This is true although the method may be in statistical control but not precise enough to distinguish differences of technical importance. It is possible to distinguish smaller and smaller differences either by increasing the amount of testing or by refining the test method, but these methods are effective only after control has been demonstrated.

The steps recommended for each test to bring it under better control are of interest because similar discrepancies undoubtedly are to be found in other laboratories. *Basis Weight:* (1) care should be exercised in cutting uniform samples, using a sharp blade to avoid fuzziness; (2) the zero point on the scales should be checked frequently, and any sluggishness of the mechanism should be corrected; (3) the method of reading should be carefully standardized, especially if interpolated between scale markings (the particular scale used may lead to preference for single swing weighing, etc.); (4) the number of test sheets weighed at once or averaged together should be standardized; (5) if an enclosed balance is used, closing of the door may be important. *Gurley Densometer:* (1) instrument should be tightly clamped; (2) allow a minimum of 25 cc. of air to permeate through the samples prior to the start of timing; (3) measure a minimum of 100 cc. for samples having lower porosities than 60 sec; (4) keep samples and equipment scrupulously clean; (5) standardize on putting the wire side next to the testing medium. *Valley Size Test:* (1) check ammeter frequently; (2) check temperature frequently; (3) frequent check and clean out of testing solution to avoid effect of increased acidity from day to day. *Carson Curl:* (1) apply attention to time of placing the sample with respect to clicking of time; (2) take care to obtain uniformity in clicking of watch after curling (i.e., at the same point in the cycle); (3) take care to cut sample correctly; (4) avoid sticking of sample; (5) avoid moving the set-up when reading results. *News Ink Penetration Test:* (1) an ample supply of the given paper should always be available in the conditioning room so that the instrument may be checked daily to see if it is reading in the proper range; (2) check the height of the ink pan when raised completely to determine if it contacts the sample properly; (3) make careful adjustment of zero point to avoid discrepancies due to change in voltage, etc.; (4) standardize on push-up.

There is a limit beyond which it is neither necessary nor economical to go in the correction of such discrepancies. However, the statistical approach provides a guide in this respect. It is a basic statistical assumption that in any process there are a myriad of small, random effects, none of which is important in itself but which taken together cause the basic variability of results. Superimposed on these are so-called assignable causes, which cause unusually large variations in results. These assignable causes may be detected and recognized by statistical means and corrected by suitable engineering action. The correction of assignable causes usually requires no important change in the test method, just greater care in its application. It is, therefore, reasonable to expect that in any worthwhile analysis of testing methods the first concern will be the detection of assignable causes, if they are present, and their removal. The sound use of the method contemplates, of course, that once the causes have been identified and removed, the continued existence of control will be insured by periodic checks of the measurement process. Having exhibited control, it will then be possible to ascribe a given precision and accuracy to the method which may confidently be said to apply as long as control exists.

USING PROCESS DATA TO ANALYZE TEST METHODS

A second valuable approach to the analysis of test methods is through the examination of process data. This approach puts dependence on certain residuals in the analytical process which may be looked upon as the inherent variability due to the test method. This would seem to be a particularly valid approach in paper testing where the effects of material variability are so inextricable. Indeed, a particular pattern of variability may be characteristic of individual machines and is most certainly characteristic of production techniques of individual mills, or even of operator shifts in a given mill. Unfortunately, however, although process data are called for, enough data are not usually taken in routine testing to satisfy the requirement of statistical analysis of test variability.

Both a larger than usual number of measurements across the paper web and a considerable number of consecutive machine direction measurements within a reel are needed. Some analysis of data of this sort has been conducted and recently the use of beta-ray gages has made much more of the necessary kind of data available. Some results have been published (*2*) and the author discussed the importance of the spacing of samples in a recent issue of *Tappi* (*3*). However, as far as is known, the idea of using the residual variances as testing error has not been developed in the literature. The errors arrived at in this way are not "pure" testing errors in the sense that effects of all other variables have been excluded. They are consciously meant to include inherent random variations in the sheet itself. In a very important sense, they may be looked upon as the most reasonable way of expressing the minimum, inherent variability of a combined production and measurement process in which we can never expect completely to separate constituent effects.

What these residuals are is really a matter for discussion with the statisticians. There is likely to be disagreement among the experts as to the meaning of the results and of the reasonableness of interpretations put upon them. But there are several methods of extracting a residual from the kind of enhanced process data mentioned, some of them depending on very simple "range" statistics, all of which seem to result in an estimate of essentially the same magnitude.

One method, using successive samples taken very close together in the machine direction is to compare observed to expected distribution of ranges of pairs of values. This procedure is repeated, skipping larger numbers of values each time until the significance test indicates no significant difference between the observed and expected distributions. The spacing between

samples at that time is the "threshold" distance mentioned earlier in this paper. Samples taken closer together are not independent. The variability of the samples at the threshold is the smallest variability in the material coming from the process that can be detected by the test method. Although it has not been used in this connection by the author, the method of serial correlation should also shed light on this problem.

The same thing can be done with measurements taken across the paper web although in this case serious stratification (that is, for example, consistently high results at the edges and low results in the middle) may also upset the expected distribution of ranges. A more elegant approach, that of fitting a curve to the cross-machine pattern by means of orthogonal polynomials may readily be carried to the point where no more assignable process causes affect the variability of the residual.

Another approach which should be given some attention is the use of a straight-forward two-way analysis of variance of data from a process in control both across the web and in the machine direction. The residual variance in this case is again a variety of minimized process variability. It involves the conception, common to all these latter approaches, of the test as a part of the total process.

Some idea of the consistency of results using these various approaches may be had from some studies of the Gurley Densometer test on paper from two machines.

For the machine direction, inherent variability by use of optimally spaced ranges was, in terms of the variance, 2.15 for machine A and 2.24 for machine B. The corresponding value from cross-machine ranges was 2.82 for A and 2.79 for B. Fitting orthogonal polynomials to the cross-machine pattern gave 3.30 for A and 1.85 for B. A two-way analysis of variance, though readily done from the available data and though probably affording a further check of this inherent variability, has not yet been tried. As they stand, the foregoing figures give little more than an index of the similarity of the alternative approaches to estimating test capabilities. A fairly reasonable check is illustrated.

One approach could be adopted, such as determining the "threshold" value in the machine direction by use of the range technique. This certainly would be a simple approach. It is directly related to one of the most important ways in which the tests are used, in control of the process.

CONCLUSION

For the few paper tests that are nondestructive, the problem of determining testing variability is much simplified. It is only necessary to pass around a number of samples and obtain a series of readings by each of several operators on the same specimens. This would work, however, for so few of the tests concerned that the more serious problem of destructive tests must be faced.

No matter how it is gone about, it will probably be found that, at first at least, discrepancies of various kinds occur in the results. Obviously, these must be taken care of if figures are to be quoted that can be used with confidence.

This makes attractive the idea of a "pre-test" to allow for removing the most obvious discrepancies before the main program is begun. The round-robin type of test has been widely used and is probably very satisfactory when the material is of good uniformity and when rules are set carefully in advance and are adhered to strictly. One may multiply the intricacy of such a program almost infinitely. It is probably as useful, if not more so, for purposes of improving the test, as for obtaining an absolute measure of its precision. Carrying out improvements on a wide scale, or even removing the most important discrepancies prior to a useful report may be more time consuming than has been realized.

There are attractive possibilities in the idea of getting test precision information within the actual framework in which the tests are used. Most of the physical properties of paper are measured in connection with process control. These all involve variable measurements for analysis of which a variety of standard, relatively simple statistical techniques are available. The attributes of paper, dirt, and defects of various kinds which lend themselves to counting do not become the object of minute scrutiny, usually, until the finishing room is reached. These kinds of tests also have particular techniques which apply. Since it is the variable test which had been considered in this paper, it is their measurement in a process context that is of interest. The problem of homogeneity of the material itself is a major aspect of the problem for paper. It is useful to increase the amount of information about the variability of the sheet at the same time as determining the inherent variability of measurement as far as it can be separated.

Although, as far as is known, the approach has not been applied widely, it is probably worth considering using the residual variance from one of several statistical approaches as a measure of testing variability. In general, these can be obtained at very little additional testing cost and the disadvantages of preparing, handling, and keeping track of special samples is avoided. It has been shown that discrepancies between various laboratories, different mills, or between seller and purchaser may be removed when they are recognized and when there is a willingness to standardize and improve the method. Therefore, the process data approach has much to recommend its consideration.

The type of analysis appropriate to any test method depends, ultimately, upon the context in which the test is to be used. The goal of a program of investigation must be clearly understood and firmly stated in advance. When that has been done, there is no doubt that modern statistical techniques have the power to make the methods better understood and to produce information that will make uniformity of performance an attainable goal.

LITERATURE CITED

1. Bicking, C. A., and Trelfa, R. T., *Tappi* 34, No. 8: 377–380 (Aug., 1951).
2. Bicking, C. A., and Trelfa, R. T., *Ind. Quality Control* 10, No. 2: 17 (Sept., 1953).
3. Bicking, C. A., *Tappi* 36, No. 12: 544 (Dec., 1953).

Received Oct. 13, 1954. Presented at the Fifth Testing Conference of the Technical Association of the Pulp and Paper Industry, Dayton, Ohio, Oct. 7, 1954.

ASSOCIATION NEWS AND EVENTS

Local Section Meetings

Pacific: Sept. 22–23, 1955, Camas, Wash.; Sept. 27–28, 1955, Seattle, Wash.; Annual Seminar, Georg Jaime, Institute of Cellulose Technology, Darmstadt, Germany, Lecturer; Sept. 29, 1955, Tacoma, Wash., "Water"; Nov. 15, 1955, Longview, Wash., "Routine Control Methods"; Jan. 10, 1956, Everett, Wash., Engineering Program; March 2, 1956, Camas, Wash., Shibley Award Program; May 17–19, 1956, Gearhart, Ore., Annual Meeting, Joint Meeting with Pacific Division, APPMS Association.

New England: Oct. 7–8, 1955, Curtis Hotel, Lenox, Mass., Joint Meeting with Connecticut Valley Division, APPMS Association; Dec. 9, 1955, Roger Smith Hotel, Holyoke, Mass.; April 6, 1956, Roger Smith Hotel, Holyoke, Mass.; June 1–2, or 8–9, 1956, Oceanside Hotel, Magnolia, Mass.

Southeastern: Sept. 30–Oct. 1, 1955, De Soto Hotel, Savannah, Ga.; Nov. 18–19, 1955, Hotel Dempsey, Macon, Ga.; Jan. 20–21, 1956, Francis Marion Hotel, Charleston, S. C.; March 23–24, 1956, Roosevelt Hotel, Jacksonville, Fla.; May 18–19, 1956, King & Prince Hotel, Brunswick, Ga.

Lake Erie: Sept. 23, 1955, Erie, Pa. "Printing and Printing Inks," Visit to mill of Hammermill Paper Co.; Nov. 18, 1955, Hotel Carter, Cleveland, Ohio, "Quality Control and Testing," Visit to plant of Thomson Products Co.; Jan. 20, 1956, Hotel Carter, Cleveland, Ohio, "Printing Equipment," Visit to the Harris Press; March 23, 1956, Steubenville, Ohio, "Production and Process Control," Visits to local paper mills; May 18, 1956, Cleveland, Ohio, Annual Meeting.

Empire State: June 7–10, 1956, Whiteface Inn, Lake Placid, N. Y.. Annual Meeting.

Empire State (Central District): All meetings held at the University Club, Syracuse, N. Y.; Oct. 7, 1955, "Corrugated Cartons"; November 4, 1955, "Automatic Steam Generation"; Dec. 2, 1955, "Mill Sanitation," by Ralph Russell, Syracuse University; Jan. 6, 1956, "Methods of Coloring Paper," by Maurice Landberge, General Dyestuff Corp., New York, N. Y.; Feb. 3, 1956, "Paper Machinery Developments"; March 2, 1956, "Converting Paper with Plastics"; April 6, 1956, "Papermaking in Europe," by Robert F. Vokes, Dilts Machine Works, Fulton, N. Y.

Empire State (Western District): Oct. 5, 1955; Nov. 2, 1955; Dec. 7, 1955; Feb. 1, 1956; April 4, 1956; May 2, 1956.

Empire State (Metropolitan District): Sept. 13, 1955; Oct. 11, 1955; Nov. 15, 1955; Dec. 13, 1955; Jan. 10, 1956; March 13, 1956; April 10, 1956; May 8, 1956.

Chesapeake and Allegheny Pulp and Paper Club: Sept. 23, 1955, Jefferson Hotel, Richmond, Va.

Maine-New Hampshire: Oct. 28–29, 1955, Lafayette Hotel, Portland, Me.

TAPPI National Conferences

Fifth Fundamental Research Conference: Institute of Paper Chemistry, Appleton, Wis., Sept. 15–17, 1955, "The Theoretical Aspects of Bleaching."

Second Mechanical Pulping Conference: Poland Spring House, Poland Spring, Me., Sept. 19–21, 1955.

Sixth Testing Conference: Sheraton-Kimball Hotel, Springfield, Mass., Sept. 28–30, 1955. Banquet Speaker, Albert E. Bachmann, Mississquoi Corp., Sheldon Springs, Vt., "Testing from the Practical Viewpoint."

Fifth Corrugated Containers Conference: Morrison Hotel, Chicago, Ill., Oct. 5–7, 1955.

Twelfth Agricultural Fibers Conference: Alton, Ill., Oct. 13–14, 1955.

Ninth Alkaline Pulping Conference: Hotel Patton, Chattanooga, Tenn., Oct. 19–21, 1955.

Tenth Engineering Conference: Rice Hotel, Houston, Tex., Nov. 7–9, 1955.

Seventh Coating Conference: Benjamin Franklin Hotel, Philadelphia, Pa., May 7–9, 1956.

Forty-First Annual Meeting

The forty-first Annual Meeting of the Technical Association of the Pulp and Paper Industry will be held at the Commodore Hotel, New York, N. Y., on Feb. 20–23, 1956.

In addition to papers to be presented at committee-sponsored sessions, there will be room on the program to include papers that individuals or companies may wish to present. The Secretary of TAPPI, 155 E. 44th St., New York 17, N. Y., should be notified immediatly by any member who may wish to present a paper.

Maine-New Hampshire

The Maine-New Hampshire Section will hold its Fall meeting at the Lafayette Hotel, Portland, Me., on Oct. 28–29, 1955.

The papers to be presented will deal with "The Use of Softwood and Hardwood Bleached Kraft Pulps in Paper."

The Worthen E. Brawn award will be made at this meeting. The committee of judges consists of John L. Parsons, E. Sutermeister, and T. H. Geiger.

Empire State Northern District

Following is the schedule of meetings to be held by the Northern District of the Empire State Section.

Oct. 13, 1955: Visit to mill of the Newton Falls Paper Co., Newton Falls, N. Y. Dinner meeting.

Nov. 10, 1955: Hotel Woodruff, Watertown, N. Y. "The Offset Printing Process and Paper Requirements," by E. A. Luscomb, Miehle Printing Press Co., Chicago, Ill.

Dec. 8, 1955: Hotel Woodruff. "Printing Problems of the Publisher and New Developments in the Printing Field," by Frank Lincoln, Springdale Laboratories, Time, Inc., Springdale, Conn.

Jan. 12, 1956: Hotel Woodruff. Students Night. Talk by Earll Church, College of Forestry, State University of New York, Syracuse, N. Y.

Feb. 9, 1956: Hotel Woodruff. Talk by representative of Sandy Hill Iron & Brass Works, Hudson Falls, N. Y.

March 8, 1956: Hotel Woodruff. "Titanium Pigments in Paper," by H. C. Brill, E. I. du Pont de Nemours & Co., Newark, Del.

April 12, 1956: Hotel Woodruff. Empire State Award Night. Presentation of competition papers.

May 10, 1956: Annual meeting.

Ohio

The Ohio Section has announced the following schedule of programs for 1955–56.

Sept. 8, 1955: American Legion Hall, Middletown, Ohio. "Optical Detection of Fiber Irregularities During Sulphite Pulping," by Georg Jayme, Technical University, Darmstadt, Germany.

Oct. 11, 1955: Hotel Manchester, Middletown, Ohio. Twentieth anniversary meeting to honor past chairmen.

Nov. 17, 1955: Hotel Manchester, Middletown, Ohio. "Management," by Charles Kluss, Joint meeting with Miami Valley superintendents.

Dec. 13, 1955: Legion Hall. "Printing," by F. A. Weymouth, Interchemical Corp., New York, N. Y.

Jan. 12, 1956: Legion Hall. "New Machinery Developments in the Industry." Dinner meeting preceded by visit to the plants of Black-Clawson Co. in Hamilton and Middletown.

Feb. 14, 1956: Legion Hall. "Stock Preparation," by James d'A. Clark, Longview, Wash.

March 8, 1956: Legion Hall. "Fiber Swelling," by I. H. Isenberg, Institute of Paper Chemistry, Appleton, Wis.

April 10, 1956: Legion Hall. Technical papers—competition.

May 10, 1956: Hartwell Club House, Cincinnati, Ohio. Annual meeting.

Books Available

The Association has on hand a number of copies of Monograph No. 10, "Bleaching of Pulp" and "Bibliography of Paper Making and U. S. Patents—1952." Both of these books were sent to all members of the Association when they were issued. Any member of the Association who joined since the books were issued may obtain copies on request to the Secretary of TAPPI.

Fifth Fundamental Research Conference

The Fifth Fundamental Research Conference will be held at the Institute of Paper Chemistry, Appleton, Wis. The general theme will be "The Theoretical Aspects of Bleaching." The meeting will be sponsored jointly by the TAPPI Pulp Purification Committee and will be held on Sept. 15–17, 1955. Registration and room reservations can be obtained by writing to Harry F. Lewis, Institute of Paper Chemistry, Appleton, Wis. Registration will be limited to two hundred persons. The program follows:

THURSDAY, SEPTEMBER 15, 1955

9:00 a.m. Theoretical Aspects of Bleaching

1. "Some Problems in Connection with the Theoretical Aspects of Bleaching," by Harry F. Lewis, Institute of Paper Chemistry, Appleton, Wis.
2. "Oxidation of Spruce Periodate Lignin and Lignin Sulphuric Acid with Chlorine Dioxide," by Clifford B. Purves, McGill University, Montreal, P. Q.
3. "Bleaching, Part I. The Chlorination of Pulp," by D. H. Grangaard, Kimberly-Clark Corp., Neenah, Wis.
4. "A Study of the Physico-Chemical Properties of Sulphate Chlorination," by F. Loschbrandt and C. V. Wetlesen, Norwegian Pulp and Paper Research Institute, Skoyen, Norway.
5. "Multistage Bleaching," by Hansjoachim Leugering, Zellstofffabrik Waldhof, Mannheim-Waldhof, Germany.

FRIDAY, SEPTEMBER 16, 1955

9:00 a.m. Theoretical Aspects of Bleaching

6. "Topochemical Chemistry of Delignification During Pulping and Bleaching," by Georg Jayme, Institute of Cellulose Chemistry, Darmstadt, Germany.
7. "The Role of pH in Bleaching," by W. Howard Rapson, University of Toronto, Toronto, Ont.
8. "Chemical Reactions Involved in Bleaching with Sodium Chlorite and Chlorine Dioxide," by Hans W. Giertz, Swedish Forest Products Research Laboratory, Stockholm, Sweden.
9. "Color Reversion Caused by Overbleaching the Carbohydrate Fraction of Pulp," by E. B. Marum, Solvay Process Div., Allied Chemical & Dye Corp., Solvay, N. Y.

Discussion

In addition to the papers that are presented there will be a general discussion of the fields in which research might properly be initiated by either of the cooperating committees. The basis of the discussion will be a work book listing many questions put to the Fundamental Research Committee by research workers in the field.

Corrugated Containers Conference

The Corrugated Containers Conference will be held at the Morrison Hotel, Chicago, Ill., on October 5–7, 1955. The program follows:

OCTOBER 5, 1955

9:30 a.m. Single Facer Operation Session

Burt Mendlin, Cornell Paperboard Products Co., Milwaukee, Wis., *Moderator*

1. "Paste Application on the Singlefacer and Doublebacker," by Walter J. Goettsch, Samuel M. Langston Co., Camden, N. J.
2. "Doublefacer Bond—Theory and Practice," by John T. Harrison, Union Bag & Paper Corp., Chicago, Ill.
3. "An Operator's Thought on Flute Contour," by Harry Wilson, Royal Container Corp., San Francisco, Calif.
4. "Single Facer Defects and Their Effect on the Strength of Corrugated Containers," by J. J. Koenig, Gaylord Container Corp., St. Louis, Mo.
5. "New Waterproof Adhesive for Corrugating," by L. O. Carlisle, A. E. Staley Mfg. Co.

2:00 p.m. Modern Diecutting Practices Session

P. Blamere, American Box Board Co., Grand Rapids Mich., *Moderator*

1. "Operating Problems in Diecutting and Creasing of Corrugated Board," by G. R. Wilmer, American Boxboard Co., Grand Rapids, Mich.
2. "Recent Developments in Corrugated Diecutting Equipment," by Albert Shields, S. & S. Corrugated Machinery Co., L. A. Wittaker, Thompson-National Press Co., Henry W. Moser, S. M. Langston Co., and Thomas Rolands, Trissel Engineering Co.
3. "Manufacture of Cutting and Creasing Dies for Corrugated Boards," by Seymour Leon, Triangle Steel Rule & Die Co.

7:45 p.m. Dinner

"The Five Plagues of Democracy," by Cameron Ralston.

OCTOBER 6, 1955

Visits to plants in Chicago of the Fort Wayne Corrugated Paper Co., Union Bag & Paper Corp., and Stone Container Corp.

Note: Registration will begin at the Morrison Hotel at 4 p.m. Oct. 5, 1955.

Note: Local arrangements are being handled by the Chicago Section of TAPPI.

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Agricultural Fibers Conference

The Agricultural Fibers Conference will be held at the Stratford Hotel, Alton Ill., on October 13–14, 1955. The program follows:

OCTOBER 13, 1955

9:00 a.m. General Session

1. "Fundamental Research in Straw Pulping—a Comparison of the Physical and Chemical Properties of Straw Pulp," by A. J. Ernst, Northern Utilization Research Branch, U.S.D.A., Peoria, Ill.
2. "Compilation of Strawboard Mill Data," by R. Burns, Jr., Weston Paper & Mfg. Co., Terre Haute, Ind.

2:00 p.m. Visit to mill of Alton Box Board Co., Alton, Ill

7:00 p.m. Dinner at Stratford Hotel

OCTOBER 14, 1955

9:00 a.m. General Session

1. Discussion of Mill Visit and Miscellaneous Strawboard Manufacturing Problems.

Ninth Alkaline Pulping Conference

The Ninth Alkaline Pulping Conference will be held at the Hotel Patten, Chattanooga, Tenn., on Oct. 19–21, 1955. Following is the tentative program:

WEDNESDAY, OCTOBER 19, 1955

9:30 a.m. General Session

J. J. Goss, Gaylord Corp., Bogalusa, La., *Moderator*

1. "The Practical Application of Statistics to Vacuum Washing," by W. B. Simmons, St. Joe Paper Co., Port St. Joe, Fla.
2. "Chemical Consumption in Kraft Cooking," by Peter B. Borlew, National Container Corp., Jacksonville, Fla.
3. "Digester Corrosion Studies," by F. Loschbrandt, Norwegian Pulp and Paper Research Institute, Skoyen, Norway.
4. "The Role of Recycled Black Liquor in Sulphate Pulping," by Victor F. Mattson, Mead Corp., Chillicothe, Ohio.
5. Panel discussion of papers.

12:30 p.m. Luncheon

2:00 p.m. General Session

T. T. Collins, Hudson Pulp & Paper Co., Palatka, Fla., *Moderator*

1. "The Foxboro Magnetic Flow Meter," by Henry S. Drinker, The Foxboro Co., Foxboro, Mass.
2. "Thermal Conductivities of Black Liquor," by W. F. Brown and W. H. Harvin, University of Florida, Gainesville, Fla.
3. "New Developments in Cleaning Recovery Boilers," by Paul West, Thilmany Pulp & Paper Co., Kaukauna, Wis.
4. "Substitutes for Salt Cake and Sulphur in the Kraft Pulping Process," by A. W. Pesch, Southern Kraft Div., International Paper Co., Mobile, Ala.
5. "Two-Stage Slaking—a Progress Report," by D. C. Gillespie and I. W. Johnson, Dorr-Oliver, Inc., Stamford, Conn.
6. Panel discussion of papers.

6:00–7:30 p.m. Hospitality Hour

Courtesy of Bowaters Southern Paper Corp. and Combustion Engineering, Inc.

THURSDAY, OCTOBER 20, 1955

9:00 a.m. General Session

Vernon Woodside, Olin-Mathieson Chemical Corp., New Orleans, La., *Moderator*

1. "Comparison of Sulphate Pulps from Mixed Tropical Woods with Industrial Kraft Pulps from Southern Hardwoods," by Karl H. Lauer, University of Alabama, University, Ala.
2. "Deterioration of Straw-Piled Pulpwood," by T. L. Gilles and G. M. Ference, Brunswick Pulp & Paper Co., Brunswick, Ga.
3. "Deterioration of Southern Pine Kraft in High Density Storage," by James E. Ayer, University of Alabama, University, Ala.
4. "New Developments in Tall Oil," by Arthur Pollak, Tall Oil Association, New York, N. Y.
5. Panel discussion of papers.

12:30 p.m. Luncheon

2:00 p.m. Semichemical Pulping Session

John N. McGovern, Parsons & Whittemore Co., New York, N. Y., *Moderator*

1. "Penetration and Diffusion in Wood. II. Comparison of Sodium and Ammonium Sulphites as Shown by Burning," by J. E. Stone, Institute of Paper Chemistry, Appleton, Wis.
2. "High-Yield Sulphite Pulping—Poplar," by W. D. Kerr and S. A. Harding, Pulp and Paper Research Institute of Canada, Montreal, P. Q.
3. "Neutral Sulphite Semichemical Pulping of Barked and Unbarked Hickories," by E. L. Keller, Forest Products Laboratory, Madison, Wis.
4. Other papers (to be announced).

FRIDAY, OCTOBER 24, 1955

9:00 a.m. Buses leave for Calhoun, Tenn.

Tour of the mill of the Bowaters Southern Paper Corp.

Tenth Engineering Conference

The Tenth Engineering Conference will be held at the Rice Hotel, Houston, Tex. Following is the program:

SUNDAY, NOVEMBER 6, 1955

4:00–10:00 p.m. Pre-Registration (Lounge Area)

MONDAY, NOVEMBER 7, 1955

8:30 a.m. Registration (Lounge Area)
9:15 a.m. General Session (Ball Room)

Opening remarks by John D. Lyall, Armstrong Cork Co., Lancaster, Pa., *General Chairman*

9:30 a.m. Hydraulics Session

K. J. Mackenzie, Eastman Kodak Co., Rochester, N. Y., *Chairman*

1. "The Flow Properties of Paper Pulp Stock Part III. Correlation of the Friction Factor, and Suspension Flow Number for Three Pipe Diameters," by Richard E. Durst, University of Maine, Orono, Me.

10:30 a.m. Sanitary Engineering Session (Ball Room)

George M. Griffith, West Virginia Pulp & Paper Co., Luke, Md., *Chairman*

1. "The Sanitary Engineering Committee—Its Scope and Objectives," by G. M. Griffith.
2. "Industry's Progress in Effluent Engineering," by Harry F. Gehm, National Council for Stream Improvement, New York, N. Y.

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11:15 a.m. General Session (Ball Room)

JOHN D. LYALL, *Chairman*

1. "Underwater Storage of Pulpwood,—Engineering Features," by M. J. Osborne, Bowaters Southern Paper Corp., Calhoun, Tenn.; R. Q. Conner, Crossett Corp., Crossett, Ark.; Willie St. Laurent, Consultant, Montreal, Que.; and F. G. Wilson, J. E. Sirrine Co., Greenville, S. C.

12:30 p.m. Engineering Division Luncheons

Industrial Engineering Committee (Hunt Room)
Corrosion Committee (Reception Room)
Electrical Engineering Committee (French Room)
Chemical Engineering Committee (Room 336)
Process Instrumentation and Control (Room to be assigned)

2:00 p.m. Mill Maintenance and Materials Session (Ball Room)

L. L. MRACHEK, The Mead Corp., Kingsport, Tenn., *Chairman*

1. "New Installation—Maintenance Work versus Contract Work," by E. L. Cowan, Bowaters Southern Paper Corp., Calhoun, Tenn.
2. "Methods of Cleaning Rubber-Covered Rolls," by R. H. Smith, Beloit Iron Works, Beloit, Wis.

3:45 p.m. Mill Maintenance and Materials Discussion Session (Ball Room)

1. "Training Programs and Methods of Training Mill Maintenance Personnel," led by E. J. Bartlett, Union Bag & Paper Corp., Savannah, Ga.

3:45 p.m. Hydraulics Discussion Session (Jade Room)

1. Discussion of session paper.

3:30 p.m. General Discussion Session (South American Room—A)

1. Discussion of "Underwater Storage of Pulpwood."

3:30 p.m. Data Sheets Committee (Hunt Room)

TUESDAY, NOVEMBER 8, 1955

9:00 a.m. Chemical Engineering Session (Ball Room)

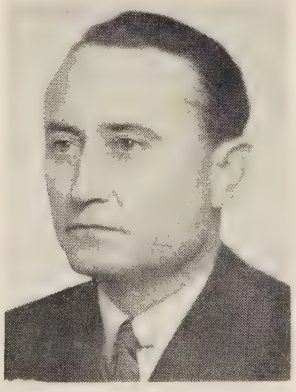
L. C. JENNESS, University of Maine, Orono, Me., *Chairman*

1. "Notes on Liquor Circulation in Digesters," by J. E. Wilkinson, Champion Paper & Fibre Co., Canton, N. C.
2. "The Thermal Compression Evaporation of Spent Pulp Mill Liquors and Its Application and Design in the Over-all Heat Balance," by R. V. Kleinschmidt, Bowen Corp., Cambridge, Mass.

9:00 a.m. Drying and Ventilating Session (South American Room—A)

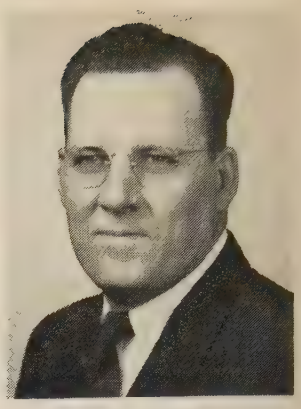
CURT A. YOUNG, Riegel Paper Corp., Milford, N. J., *Chairman*

W. L. McHale, Southland Paper Mills Inc., Member Sponsoring Committee, Engineering Conference



R. M. Buckley, East Texas Pulp & Paper Co., Member Sponsoring Committee, Engineering Conference

K. R. Bendetsen, Champion Paper & Fibre Co.; Member Sponsoring Committee, Engineering Conference



D. C. Edmiston, Southland Paper Mills, Inc., Local Arrangements Committee, Engineering Conference

1. "Air Filtration for the Pulp and Paper Industry," by J. W. May, American Air Filter Co., Louisville, Ky.

10:30 a.m. Corrosion Engineering Session (Ball Room)

S. J. BAISCH, Thilmany Pulp & Paper Co., Kaukauna, Wis., *Chairman*

1. "Experience with Digester Corrosion in a Mexican Pulp Mill," by A. A. Tirado, Fabrica de Celulosa, Tlalpam, D. F., Mexico.
2. "Digester Design and Its Effect on Digester Corrosion in Alkaline Pulping," committee report presented for the committee by L. G. Pfeiffer, A. O. Smith Corp., Milwaukee, Wis.

10:30 a.m. Industrial Engineering and Materials Handling Session (South American Room—A)

J. M. MACBRAYNE, Union Bag & Paper Corp., Savannah, Ga., *Chairman*

1. "The Question of Power Selection for Plant Industrial Trucks," Panel Discussion by L. F. Carriker, Union Bag & Paper Corp., Savannah, Ga.; D. D. Hall, E. B. Eddy Co., Hull, P. Q., Canada; W. A. McKenzie, Simpson Paper Co., Everett, Wash.; and L. P. Rowley, Lockheed Aircraft Corp., Burbank, Calif.
2. "Tomorrow's Methods Today—Automation in Action," by Gilbert Moree, Supervisor of Design Section, Ford Motor Co., Dearborn, Mich.

12:30 p.m. Engineering Division Luncheons

Sanitary Engineering Committee (Reception Room)
Engineering Research and Machine Design Committee (Hunt Room)
Steam and Power Committee (French Room)
Hydraulics Committee (Room 336)
Mill Planning and Economics (Room 347)
Mill Maintenance and Materials (Room to be assigned)

2:00 p.m. Electrical Engineering Session (Ball Room)

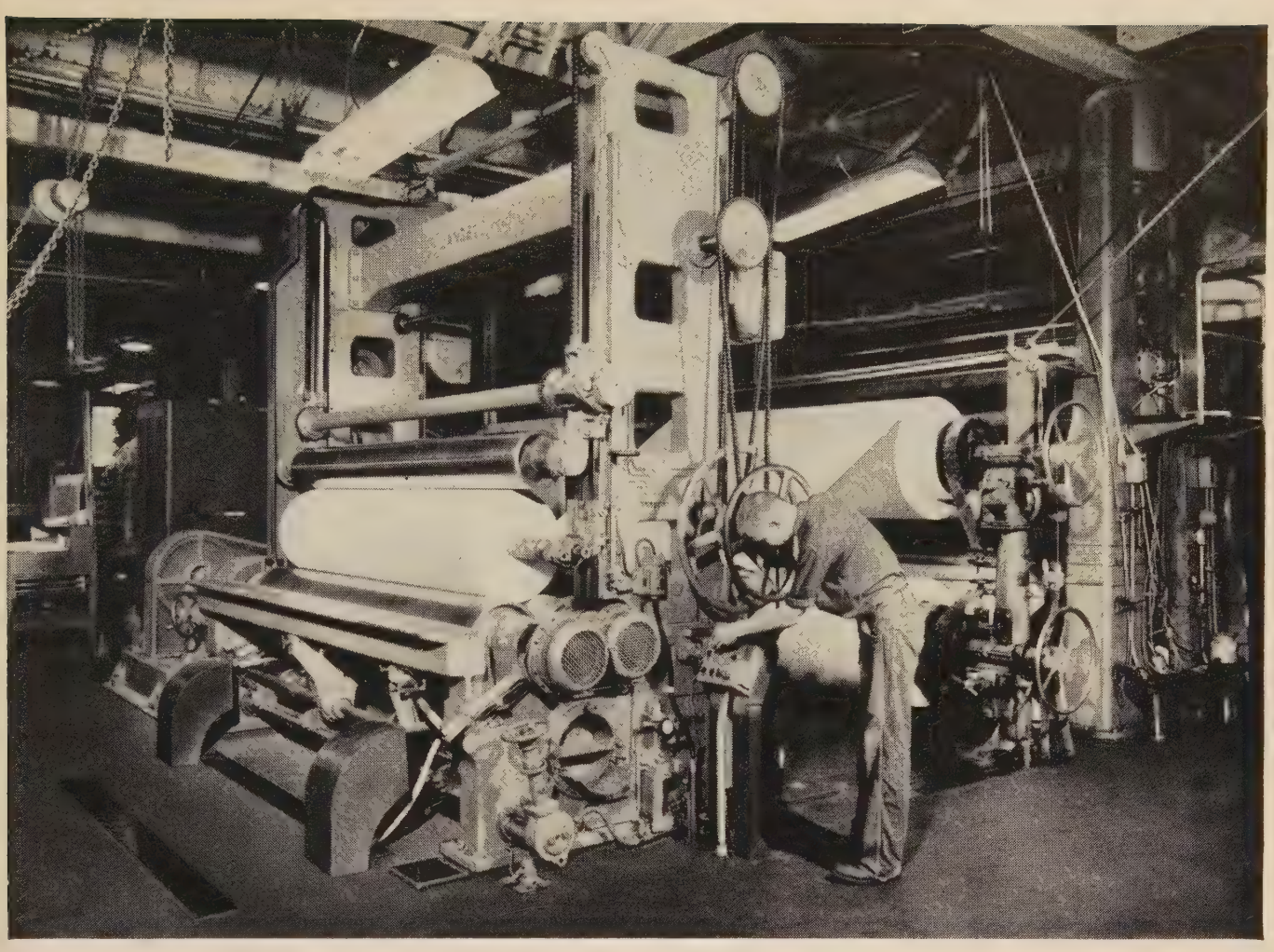
M. J. OSBORNE, Bowaters Southern Paper Corp., Calhoun, Tenn., *Chairman*

1. "Preventive Maintenance for Paper Mill Rotating Machinery," by N. L. Danforth, St. Regis Paper Co. Bucksport, Me.
2. "Paper Mill Lighting Design and Economics," by H. C. Swannell, J. E. Sirrine Co., Greenville, S. C.

3:45 p.m. Electrical Engineering Discussion Session (Ball Room)

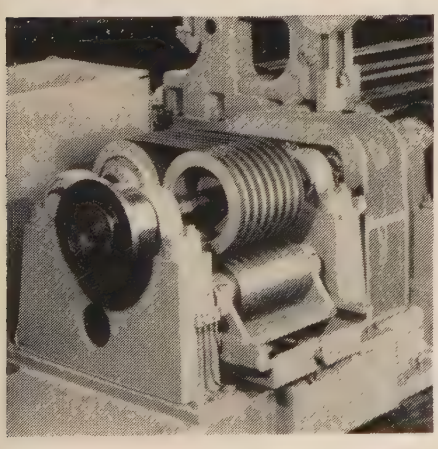
"Pulp and Paper Mill Power Distribution," Symposium led by S. A. Bobe, Westinghouse Electric Corp., Atlanta, Ga.

1. "Selection of Voltage in the Design of Pulp and Paper



Typical tough winding job is this fine writing paper handled by Langston Slitter & Winder at Wausau Paper Mills Co., Brokaw, Wis. Engineered controls enable precise adjustment of rider roll pressure and drum overspeed for consistent, optimum roll density.

Facts about roll density and **Langston Slitters & Winders**



Variable pitch sheave is adjustable on high speed Langston Winders to vary overspeeds of rear drum and rider roll simultaneously. Because they are quiet, require little maintenance, and are more efficient than flat belts, only V-belts are used on Langston Winders.

Wind a roll too tight, and it may burst or buckle. Too loose, and it may telescope. There is an ideal roll density for each thickness and strength of paper—which Langston Slitters & Winders are designed to provide.

Rider roll pressure, for example, is variable over a wide range and can be closely controlled to suit varying kinds of paper. This is especially important at the start of the wind—before the roll picks up weight of its own.

On high speed Langston Winders using V-belt drive, controllable overspeeds of rear drum and rider roll keep sheet constantly taut as it is wound. Tension can be further controlled within close limits by one of a variety of different braking systems on the unwind stand.

Other advantages of Langston Slitters & Winders include the clean-cutting, shear-cut slitters, strong sturdy bedplate and sideframes, and hydraulic roll ejector and shaft loader available on most models. Sizes to 196 inches wide and speeds to meet your specifications. Write for full information. Samuel M. Langston Co., Camden 4, N.J.

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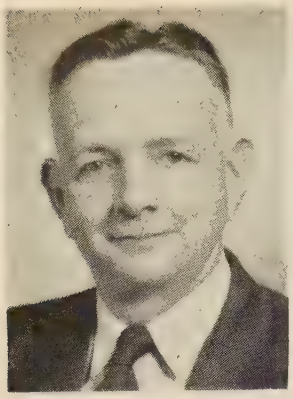
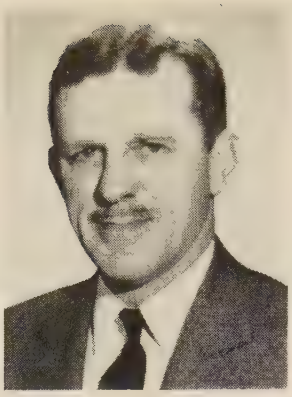


J. S. Hartman, East Texas Pulp & Paper Co.; Local Arrangements Committee, Engineering Conference



Stephen Chase, Jr., Champion Paper & Fibre Co.; Chairman, Local Arrangements Committee, Engineering Conference

Mill Distribution Systems," by H. C. Swannell, J. E. Sirrine Co., Greenville, S. C.

2. "Expansion of Power Distribution in Paper Mills," by H. B. Greear, General Electric Co., Atlanta, Ga.
3. "Selection of a Distribution System in Designing a New Paper Mill," by W. M. Emmons, Westinghouse Electric Corp., Atlanta, Ga.
4. "Commutation Problems of the Paper Mill—a Progress Report," by D. E. Bivins, Jr., Brown Paper Mills, Monroe, La.
5. "Presentation of a Data Sheet—Down Time of Electrical Sectional Drives," by H. F. Sorenson, Union Bag & Paper Corp., Savannah, Ga.

3:45 p.m. Chemical Engineering Discussion Session (Reception Room)

1. Discussion of session papers.

3:45 p.m. Industrial Engineering and Materials Handling Discussion Session (Sam Houston Room)

1. Discussion of session papers.

3:45 p.m. Drying and Ventilating Discussion Session (room to be assigned)

1. Discussion of session papers.

6:00 p.m. Social Hour

7:00 p.m. Dinner (Ball Room)

WEDNESDAY, NOVEMBER 9, 1955

9:00 a.m. Steam and Power Session (South American Room—A)

W. M. Wyburn, Federal Paper Board Co., Inc., Bogota, N. J., *Chairman*

1. "Sulphite Liquor Burning," by Frank H. Coldwell, Nekoosa-Edwards Paper Co., Port Edwards, Wis.
2. "Work Scheduling on Steam Plant Equipment," by A. F. Richard, Champion Paper & Fibre Co., Hamilton, Ohio.

10:30 a.m. Engineering Research and Machine Design Session (South American Room—A)

R. E. Quinn, Johns Manville Research Center, Manville, N. J., *Chairman*

1. "Crystal Balls for System Designers," by R. C. Berger, General Electric Co., Cleveland, Ohio.
2. "Performance and Design of Paper Stock Mixers," by J. Y. Oldshue and A. T. Gretton, Mixing Equipment Corp., Rochester, N. Y.

12:30 p.m. Engineering Division Luncheon (Ball Room)

Address by G. W. E. Nicholson, Union Bag & Paper Corp., New York, N. Y.

2:30 p.m. Mill Planning and Economics Session (South American Room—A)

R. A. Packard, Consultant, Hopkinton, Mass., *Chairman*

1. "Nonengineering Factors Influencing Mill Expansion" (a dramatization; participants to be announced).

3:45 p.m. Mill Planning and Economics Discussion Session (South American Room—A)

1. Discussion of session topic.

3:45 p.m. Steam and Power Discussion Session (Sam Houston Room)

1. Corrosion in Boilers and Accessories (panel discussion, panel members to be announced)

3:45 p.m. Engineering Research and Machine Design Discussion Session (Jade Room)

1. Discussion of session papers.

6:00 p.m. Dinner Meeting for Committee Chairmen and Secretaries (Hunt and Jade Room)

THURSDAY, NOVEMBER 10, 1955

Mill Tours:

A. Champion Paper & Fibre Co., Pasadena, Tex.
B. Southland Paper Mills, Inc., Lufkin, Tex.
C. East Texas Pulp & Paper Co., Evadale, Tex.

Tenth Plastics-Paper Conference

The Tenth TAPPI Plastics-Paper Conference will be held at the Brooklyn Law School, 375 Pearl St., Brooklyn, N. Y., Nov. 14 and 15, 1955. The program for the conference follows:

MONDAY, NOVEMBER 14, 1955

9:00 a.m. "Fibrous Materials for Laminates"

Paul M. Goodloe, Brown Paper Co., Berlin, N. H., *Chairman*

1. "Some Factors Influencing the Crazing Tendency of Laminates," by Hans Arledter, Hurlbut Paper Co., South Lee, Mass.
2. "The Forming Machine—Its Use in Sheet and Preforming Operations," by Frank Hayes, Noble & Wood Machine Co., Hoosick Falls, N. Y. and F. Carlton Loeber, The Forming Machine Co. of America, Hoosick Falls, N. Y.
3. "Kraft and Synthetic Fiber Pulp Mats for Laminates," by L. P. Wenzell, Celanese Corp., Charlotte, N. C.
4. "Paper- Laminate Property Relationship," by George Shaw, Taylor Fibre Co., Norristown, Pa.
5. "Testing Paper for Resin Saturating Qualities,"—Panel Discussion.

2:00 p.m. "Resins Employed in Laminates"

H. F. Mark, Brooklyn Polytechnic Institute, Brooklyn, N. Y., *Chairman*

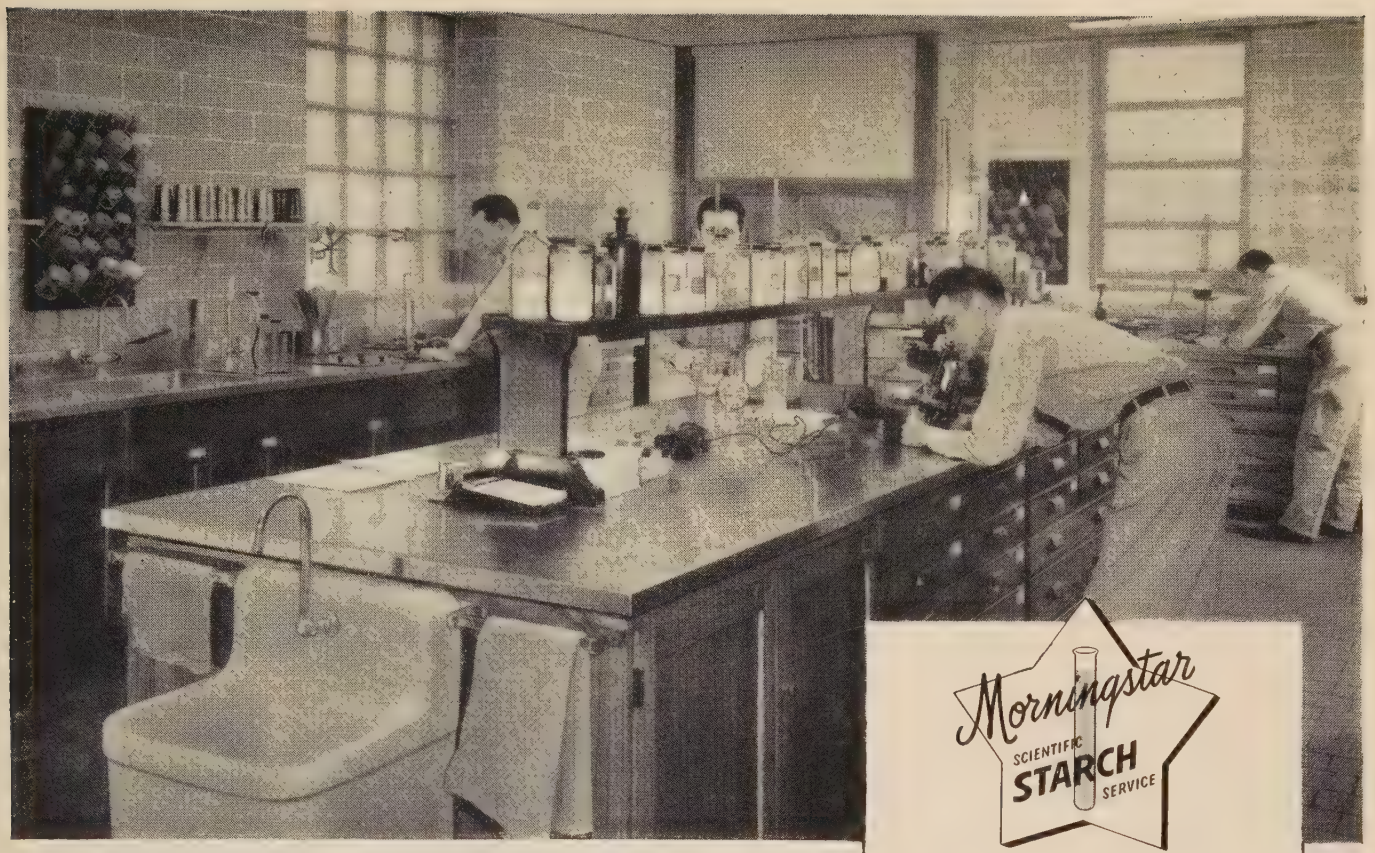
1. "Board Surfacing Resin," by V. V. Lindgren, American Cyanamid Co., New York, N. Y.
2. "Metal Organic Polymers and Their Use with Fibers," by H. C. Brill, E. I. du Pont de Nemours & Co., Wilmington, Del.
3. "Polyesters," speaker to be announced.
4. "Epoxy Resins," speaker to be announced.

TUESDAY, NOVEMBER 15, 1955

9:00 a.m. "The Pulp and Paper Industry Speaks on Its Plastics Requirements"

W. C. Stickel, Texon Inc., South Hadley Falls, Mass., *Chairman*

1. "Specialty Papers," by J. Helms, Marathon Corp., Rothschild, Wis.
2. "Glassine and Greaseproof," by Ralph Nazzarro, Westfield River Paper Co., Russell, Mass.



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3. "Boxboard," by A. T. Luey, Boxboard Research & Development Assn., Chicago, Ill.
4. "Cup and Container," speaker to be announced.

12:30 p.m. Luncheon Bossert Hotel, 98 Montague St., Brooklyn, N. Y.

Speaker—Charles Lewis, Director, Container and Packaging Div., U. S. Dept. of Commerce, Washington, D. C.

2:30 p.m. "Polyethylene Extrusion Coating"

R. C. STURKEN, Frank W. Egan & Sons, Somerville, N. J., *Chairman*

1. "Physical Properties of Papers Coated with Polyethylene by Extrusion," by K. A. Arnold, St. Regis Paper Co., Deferiet, N. Y.
2. "Performance and Design Data of Cooling Rolls on Polyethylene Extrusion Laminating Machine," by W. R. Penrod, Dilts Machine Works, Fulton, N. Y.
3. "A Comparison of Polyethylene and Polyethylene-Wax Coating," by J. C. Rice, Lowe Paper Co., Ridgefield, N. J.
4. "Polyethylene Extrusion Lamination—Equipment Design and Operation," by E. C. Bernhardt, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.

Dirigo

At the request of the Editor, Frank A. Butler of the Eastman Kodak Co. has prepared the following brief story about *Dirigo*, the organization of the graduates of the Five-Year Course in Pulp and Paper Management of the University of Maine. Mr. Butler is secretary-treasurer of *Dirigo*.

Dirigo was formed by the first graduates of the Five-Year Course in Pulp and Paper Management at the University of Maine. The first scholarship recipients were very much impressed by the motives behind the formation of the University of Maine Pulp and Paper Foundation and the efforts of the faculty at the University of Maine to set up a course which would meet the requirements. As a result of the meetings which Professor Jenness called of the faculty and the first group of students, a strong interest developed within the student group to maintain contact with each other and to follow the progress of the program and its graduates.

Therefore, on March 17, 1952, the student group met in 106 Hannibal Hamlin Hall to discuss establishing some sort of association to provide for communication, exchange of information, and to foster a group spirit. It was decided that control of the group to be formed should be maintained in an executive board composed of the charter members until the organization became stable and that the officers should change each year by alphabetical rotation among the board. John McClure became the first president and Roy Webber was secretary-treasurer. Frank Butler, Dwight Frye, and Robert Zabe worked as a constitution committee to draw up the constitution. After several weeks the constitution was formalized and it was ratified on May 5, 1952, by the seven charter members. Lyle Jenness was subsequently made a member of the executive board to give the board its present complement of eight men. Dues were set temporarily at $1.50 a year and have been adequate so far.

In the past three years Dirigo has served its members by publishing five newsletters and has helped one man relocate to a better job. Presently, the group is attempting to prepare a short brochure in which the members will describe the types of work they have done since graduation. This brochure will be sent to Lyle Jenness to distribute to prospective graduates as early as possible in their last school year. It is hoped that this will help give the students some idea of what is involved in industrial jobs and how jobs of similar titles vary widely from company to company. We feel that this information from several sources might help to give the student a clearer idea of actual job requirements and should help to form a basis for intelligent questions while interviewing.

The group is growing slowly, but it is already evident that the secretary-treasurer cannot be expected to maintain correspondence personally with all members. Therefore, Robert Chase, who is staying on at the University of Maine as an instructor, has been selected as secretary for the class of 1955 and will maintain liaison between his class members and the secretary-treasurer. It is planned to have each future class represented by a secretary to provide for rapid communication.

The present officers are Robert Zabe, president, and Frank Butler, secretary-treasurer and their present job affiliation is enclosed. As stated previously, officers are changed each year by alphabetical rotation among board members (with the exception of Professor Jenness).

Fourth Statistics Conference

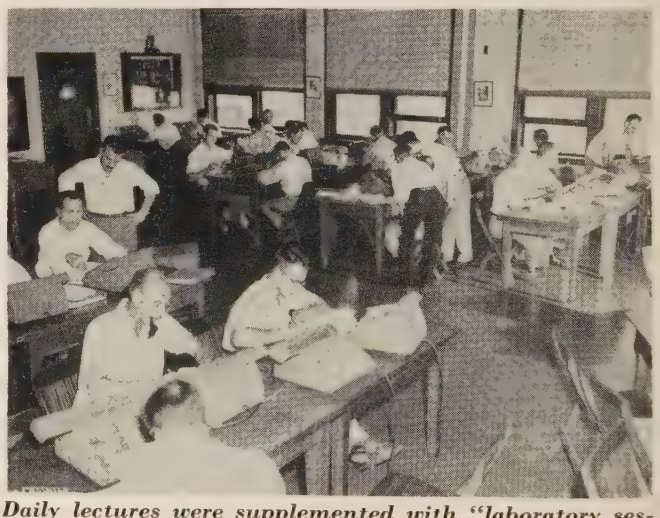
Thirty-eight representatives of pulp and paper industries in the United States and Canada spent July 11–22 at the U. S. Forest Products Laboratory, Madison, Wis., learning how modern statistical techniques can help them produce better pulp and paper products. The 2-week meeting was the fourth annual TAPPI Statistics Conference, co-sponsored this year by the Forest Products Laboratory and the Technical Association of the Pulp and Paper Industry.

The conference was designed to give basic training in statistical methods and to refresh and increase the knowledge of men who had previous training.

Many pulp and paper companies are already making profitable use of statistics, but many more companies of every size could obtain better quality control, more uniform products, and reduced testing costs if they had men trained in the use of modern statistical techniques.

This year's conference consisted of two separate, concurrent courses—elementary and advanced, with specific paper-industry applications emphasized in both of them.

Geoffrey Beall, chairman of the Department of Statistics of the University of Connecticut, Storrs, Conn., was in charge of instruction, aided by Mason Wescott, Rutgers University, New Brunswick, N. J.; Maurice Tatsuoka, Harvard University, Cambridge, Mass.; C. E. Nobel, Kimberly-Clark Corp., Neenah, Wis.; and Maynard S. Renner, Dewey & Almy Chemical Division, W. R. Grace & Co., Cambridge, Mass.



Daily lectures were supplemented with "laboratory sessions" in which the men actually worked out statistical analyses of problems dealing with the pulp and paper industry

The advanced course was designed for men with previous experience and definite facility in the use of statistical tech-

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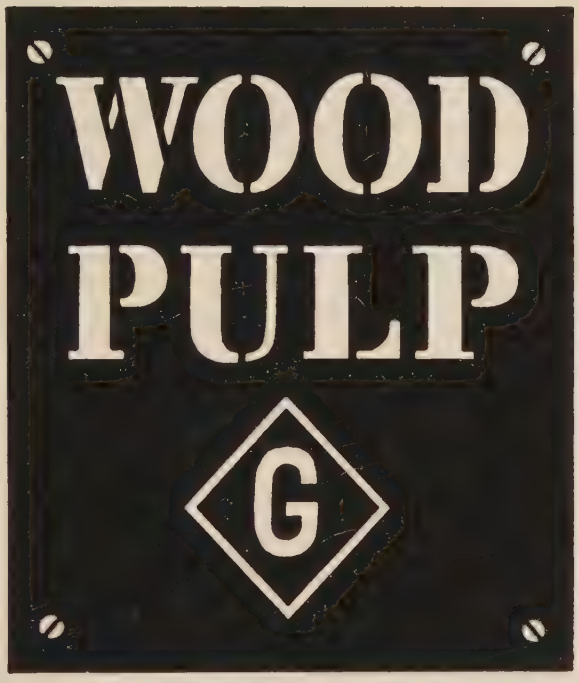

"When liberty is gone, life grows insipid."

ADDISON

Wherever freedom shines, paper performs a vital function. Freedom thrives on the exchange of ideas, circulated and stimulated by fearless publication—and it takes a lot of paper to record tastes and opinions that are free to clash.

But where the light of freedom dims, and dull uniformity settles over the land, paper is robbed of its most glorious task, and life of its interest.

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niques. The course was run as a seminar on the detailed analysis of specific and somewhat involved mill problems.

The enrollees of the advanced course brought their own specific problems. As a result, the seminar sessions resembled the technical conferences that take place within mills, except that an experienced statistician was present to help the business along.

Enrollees included chemists, chemical engineers, quality

Geoffrey Beall, chairman of the department of statistics, University of Connecticut, conducts advanced seminar in statistical problems in the pulp and paper industry at the fourth annual TAPPI Statistics Conference, held at the U. S. Forest Products Laboratory, Madison, Wis., July 11–22, 1955

control engineers, research and testing specialists, and statisticians from pulp mills, paper mills, container manufacturers, converters, and the Forest Products Laboratory.

The experience of the registrants was as varied as their technical background. Some of the men had no previous experience with statistical methods, while others had been working with statistics for some time and wanted to increase their understanding of methods and learn new techniques, Mr. Beall said.

The conference began with a full day's briefing on the operation of calculating machines. Manufacturers of the Friden, Marchant, and Monroe calculators had provided enough calculators so that each man in the course had one at his disposal. Representatives of each of these companies were present to give instruction in the use of their machines.

The subject matter of the elementary course was chosen to give an introduction to the most valuable and useful of the techniques of experimental statistics. The first week covered chance variable of measurement, the significance of a difference in the present of variability, analyses of variance, and an introduction to design of experiments.

The second week was concerned with largely regression and correlation techniques; that is, techniques by which the relationship between two or more variables can be determined and their magnitude estimated, whether they occur in the mill, the test laboratory, or the research laboratory.

The course was a combination of lectures and laboratory sessions in which the men worked out industry problems that related to each day's lectures. The lectures and laboratory work were supplemented by informal meetings in which the instructors went into detail on specific phases and gave individual assistance to any student desiring it.

These "skull sessions," as one student called them, enabled the men to get answers to questions or straighten out any uncertainties while the lecture material was still fresh in mind.

Much of the information given the men during the course was highlighted in evening addresses by guest speakers chosen from companies that are now making profitable use of statistical methods.

These speakers were: E. R. Hoffman, chief statistician, Oxford Paper Co., Rumford, Me.; Carl E. Noble, manager, customer acceptance department, Kimberly-Clark Corp., Neenah, Wis.; B. E. Sooy, production manager, Wolverine Carton Co., Grand Rapids, Mich.; T. A. Pascoe, research director, Nekoosa-Edwards Paper Co., Port Edwards, Wis.

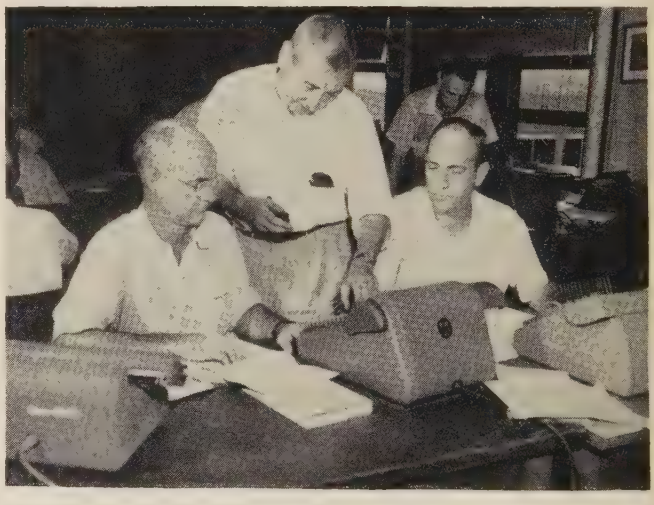
The opinion of the advanced group was pretty well summed up by one man who said the course "helped him straighten out his thinking." One hour with Messrs. Beall and Wescott saved him what would amount to several weeks' work back at the plant, he said.

Another advanced student said the seminar sessions not only served as a refresher course, but that the new techniques he learned would give him an entirely new approach to several vexing problems he is now investigating for his company.

Value of both courses was also attested by the fact that many of the men were the second or third representatives of their companies to attend TAPPI conferences.

One man in the elementary course, the second to be sent to the conference by his company, said the techniques learned by the first man helped the company set up a quality-control program that cut below-standard pulp from 5% to less than 1%.

The following men were enrolled at the conference: T. W. Bauer, Central Research Division, Abitibi Power and Paper Co., Ltd., Ontario, Canada; J. B. Brown, Crown Zellerbach Corp., Central Research Dept., Camas, Wash.; D. R. Carlson, Gardner Board & Carton Co., Middletown, Ohio; W. E. Carlson, Whiting-Plover Paper Co., Stevens Point, Wis.; R. R. Fuller, Gulf States Paper Corp., Tuscaloosa, Ala.; E. R. Hoffman, Oxford Paper Co., Rumford, Me.; W. R. Saxton, Industrial Cellulose Research, Ltd., Hawkesbury, Ontario, Canada; G. H. Daldauf, Ecusta Paper Corp., Pisgah Forest, N. C.; D. C. Cullingham, Canadian International Paper Co., Quebec, Canada; H. D. Davis, Crown Zellerbach Corp., Packaging Research & Development, San Leandro, Calif.; D. F. Dykes, Macon Kraft Co., Macon, Ga.; G. T.



Maynard S. Renner, Dewey & Almy Chemical Co., Division W. R. Grace & Co., gives personal instruction to students in informal meetings that supplemented regular lectures and laboratory sessions

Edmonds, The Chesapeake Corp. of Virginia, West Point, Va.; A. R. Ewing, Bemis Bros. Bag Co., Boston, Mass.; F. E. Field, Sutherland Paper Co., Kalamazoo, Mich.; W. C. Grater, Bowaters Southern Paper Corp., Calhoun, Tenn.; C. W. Guelcher, Nekoosa-Edwards Paper Co., Port Edwards, Wis.; L. J. Manders, Charmin Paper Mills, Green Bay, Wis.; W. W. Marteny, National Container Corp., Tomahawk, Wis.; D. O. Newton, St. Regis Paper Co., Pensacola, Fla.; H. J. Ostrowski, Hinde & Dauch Paper Co.,

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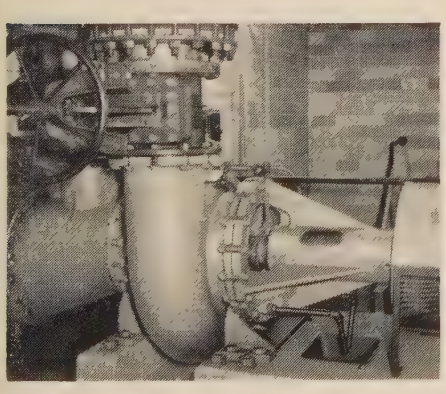
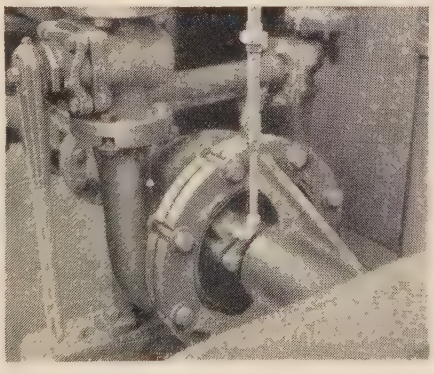
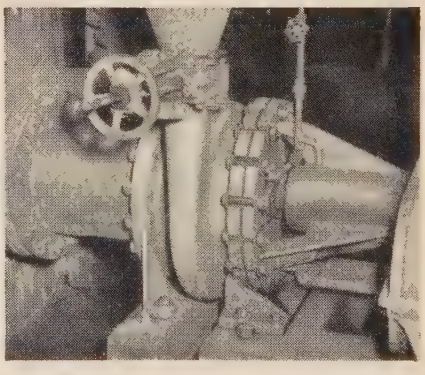


0.7% stock from bull screens — handled by this type PW 16 x 14 pump. With only one basic design this mill can carry fewer spare parts in stock.



1.1% specific gravity milk of lime is pumped by this type PW 4 x 3 pump. *Texrope* V-belt drive permits easy varying of head and capacity of pump.



4.4% stock (heaviest in the mill) is handled by this type PW 16 x 4 pump. Standardization saves maintenance time because men have fewer types to work on.

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Tenth Engineering Conference

A panel will present and discuss Economic Factors Influencing Mill Expansion as a feature of TAPPI's Mill Planning Economics Committee's program at the Tenth Engineering Conference to be held in Houston, Nov. 9, 1955.

The panel will be made up of people from the fields of Finance, Marketing, Taxation, Organization and Personnel Planning, and Research and Development. The panel will outline the important factors in each field which encourage or inhibit expansion in general or some forms of expansion that appear to be logical from a production or engineering viewpoint.

Last year's Philadelphia conference paper entitled "Paper Mill Rehabilitation Involving Rebuilding Old Paper Machine Versus a New Machine" (see *Tappi* magazine, July, 1955) by John A. McPherson and Harold G. Ingraham, proved so popular and the differences in opinion so marked in the discussion that only standing room was available for the discussion. It was therefore decided by the committee to continue another aspect of the same subject for this year's program.

Howard Baumgarten, economist and member of the executive staff of Parsons & Whittemore, Inc., New York City, will act as moderator of the panel and the discussion.

The program will be of interest to all paper industry personnel who have any part in planning mill expansion. Engineers and production people will hear about some of the other fields that affect what they think is "obviously logical." Finance, administration, marketing, and others will hear some stimulating ideas in their own and related fields. *It is hoped that liberal leaves to all types of personnel who do any planning will be granted to go to Houston this November.*

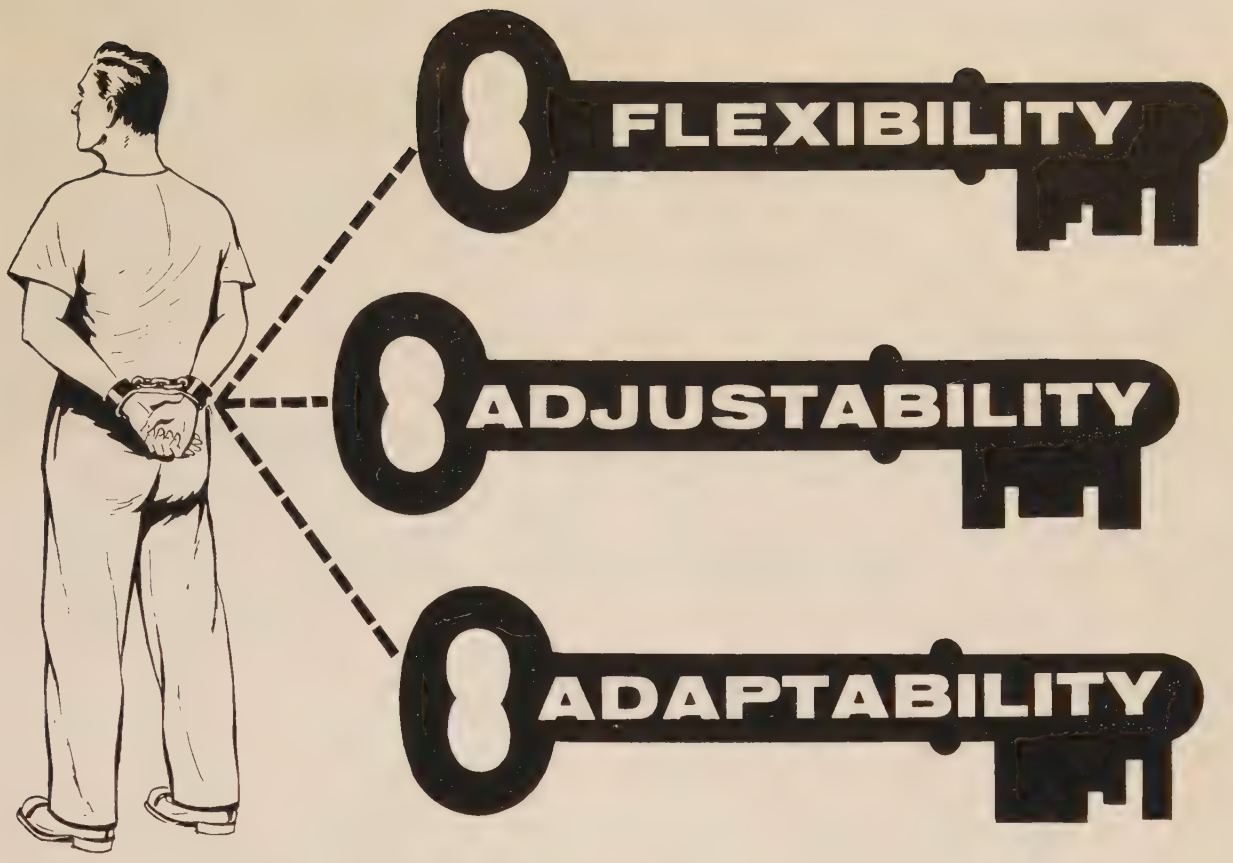
Research Appropriations Committee

Semi-Annual Report of the Research Appropriations Committee covering requests for funds January to June, 1955.

Request no.	*Project*	*Committee*	*Amount*
75	The Reactions of Aqueous Chlorine Solution with Simple Carbohydrates	Fundamental Research	$ 5,750.00
76	(1) An Examination of the structure of the Uronic Acid Components of the Hemicelluloses of Woods (continued) (2) The Action of Acid on Pentose and Hexose Sugars (Reversion)	Fundamental Research	4,450.00
77	Studies in the Preparation and Chemical Properties of the Polymer-homologous Oligosaccharides of the Cellulose Series		1,800.00
78	The Behavior of Nucleophilic Reagents with Lignin Models	Fundamental Research	4,448.65
79	A Study of Sulphur Chemistry as Related to the Kraft Process	Fundamental Research	2,500.00
80	Review of the Literature on Beater or Wet End Additives	Fundamental Research	500.00
81	Friction of Paper Stock in Pipes (continued)	Hydraulics	5,000.00
82	Identification of Sulphite Waste Liquor Components	Acid Pulping	4,900.00
83	Development of a Standard Method for Analysis of Mill Wastes Solids Determination by Buchner vs. Gooch Methods (continued)	Water	1,500.00
84	Power Requirements for Paper Machines	Electrical Engineering	1,500.00
	Total requests granted		$32,348.65

All requests for funds submitted during the first half of 1955 have been granted by the Research Appropriations Committee, most of them unanimously. Although the total amount of money granted during these first six months constitutes a record high, too few committees avail themselves of the opportunity of expediting their projects with the use.

JOHN L. PARSONS, *Chairman*



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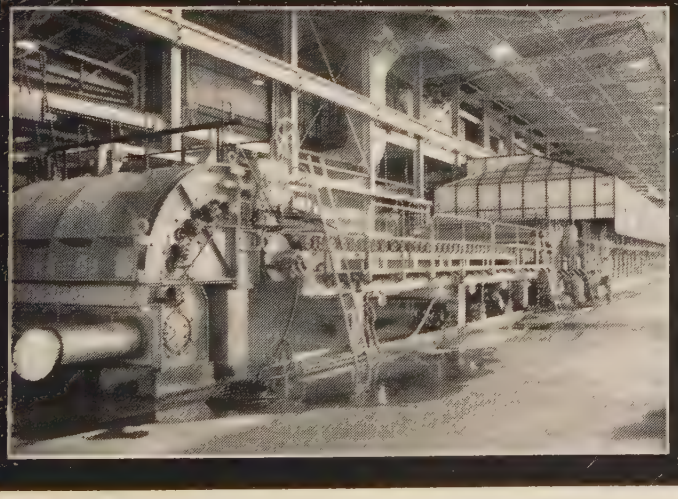

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PERSONAL MENTION

Items About New and Old Tappimen

New TAPPI Members

Benjamin C. Aldrich, Technical Representative, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del. Attended Harvard University.

Jay M. Armstrong, Sales Engineer, National Starch Products, Inc., New York, N. Y., a 1949 graduate of Syracuse University.

C. Gordon Biesenthel, Chief Engineer, The Alexander Fleck Ltd., Ottawa, Ont., Canada, a 1938 graduate of Queen's University.

Adrian R. Boller, Sales Representative, Riordon Cellulos S. A., Paris, France.

Eugene F. Boutilier, Assistant Electrical Engineer, S. D. Warren Co., Cumberland Mills, Me., a 1948 graduate of the University of Maine.

O. J. Bristow, Jr., Engineering Technician, Union Bag & Paper Corp., Savannah, Ga. Attended Armstrong College.

Marvin H. Buhner, Mechanical Engineer, Fox River Paper Corp., Appleton, Wis., a 1942 graduate of the University of Wisconsin.

Julio Colon, Accountant, La Aurora, S. A., Mexico, D. F., Mexico, a 1936 graduate of Deutsche Oberrealschule, Madrid.

Harold E. Corwin, Technical Co-ordinator, Syracuse University Research Institute, Syracuse, N. Y., a 1940 graduate of the College of the City of New York, with a Ph.D. degree from Syracuse University in 1952.

Howard F. Cromwell, Salesman, Catalin Corp. of America, New York, N. Y., a 1951 graduate of New York State College of Forestry.

Gerrit H. deReus, Chief Engineer, John W. Bolton & Sons, Inc., Lawrence, Mass., a 1944 graduate of the Academy of Rotterdam.

James L. Dickerscheid, Research Project Engineer, Champion Paper & Fibre Co., Hamilton, Ohio, a 1952 graduate of the University of Cincinnati.

Jackson F. Dunn, Pulp Mill Superintendent and Chemist, The Mead Corp., Sylva, N. C., a 1947 graduate of North Carolina State College.

David Evans, Student, New York State College of Forestry, Syracuse, N. Y.

Harry M. Farnham, Jr., Sales Engineer, Esso Standard Oil Co., 15 W. 51st St., New York 19, N. Y., a 1949 graduate of the University of New Hampshire.

Arthur Goldman, Technical Representative, Airkem, Inc., New York, N. Y., a 1938 graduate of Ohio University, and a 1950 graduate of Brooklyn Polytechnic Institute.

Glenn A. Goldsmith, Research Chemist, Mosinee Paper Mills Co., Mosinee, Wis., a 1953 graduate of the University of Wisconsin.

John C. Gresham, Application Engineer, General Electric Co., Schenectady, N. Y., a 1944 graduate of Union College.

Humert G. Guy, Manager, Kobuta Chemical Section, Koppers Co., Inc., Pittsburgh, Pa., a 1934 graduate of Ohio State University.

Thomas B. Harrison, Resident Engineer, The Ontario-Minnesota Pulp & Paper Co. Ltd., Port Frances, Ont., Canada, a 1934 graduate of the University of Saskatchewan.

Lloyd D. Hayward, Assistant Professor of Chemistry, University of British Columbia, Vancouver, B. C., Canada, a 1949 graduate of McGill University with a Ph.D. degree.

Paul D. Hubbe, Steam Engineer, Great Northern Paper Co., Millinocket, Me., a 1949 graduate of Massachusetts Institute of Technology.

Tom F. Hubrecht, Managing Director, Van Gelder Zonen N. V., Royal Paper Mills, Amsterdam, The Netherlands, a graduate of the Technical University at Delft.

Thomas R. Johnson, Chief Research Chemist, Thames Board Mills Ltd., Purfleet, Essex, England, a 1920 graduate of the College of Technology, Manchester.

George L. Keith, Assistant Town Engineer, Anglo-Newfoundland Development Co. Ltd., Grand Falls, Nfld., a graduate of Wandsworth Technical Institute, England.

Thomas L. Kirtley, Assistant Chief Chemist, Hercules Powder Co., Hopewell, Va., a 1942 graduate of the California Institute of Technology.

Joseph G. Kisser, Professor, Osterreichischen Holzforschungs Institut, Vienna, Austria, a 1922 graduate of the University of Vienna with a Ph.D. degree.

Albert S. Landers, Technical Sales Service, Philadelphia Quartz Co., Philadelphia, Pa., a 1937 graduate of the University of Maine.

Karl H. Lauer, Visiting Professor, Pulp and Paper Research, University of Alabama, School of Chemistry, University, Ala., a graduate of the University of Vienna with a Ph.D. degree.

Hubert D. MacDonald, Assistant District Manager, The Ohio Knife Co., Cincinnati, Ohio. Attended the University of Illinois.

Floyd I. Moore, Paper Control Superintendent, Howard Smith Paper Mills Ltd., Cornwall, Ont., Canada.

William B. Mosely, Research Assistant, St. Regis Paper Co., Pensacola, Fla. Attended Clemson A. & M. College.

Lawrence W. Murtfeldt, Pulp Superintendent, Consolidated Water Power & Paper Co., Wisconsin Rapids, Wis., a 1930 graduate of Washington University.

Freeman A. Nichols, Paper Mill Superintendent, Spruce Falls Power & Paper Co. Ltd., Kapuskasing, Ont., Canada, a 1931 graduate of the University of Minnesota.

Lewis C. Oseland, Assistant Manager, The Carpenter Steel Co., Kenilworth, Ill. Attended Minnesota College and Lewis Institute.

Richard R. Peck, Chemist, Southern Chemical Cotton Co., Chattanooga, Tenn., a 1951 graduate of the University of Chattanooga.

Fritz Peters, Proprietor, Fritz Peters & Co., K.G., Krefeld, Germany.

David E. Robinson, Design Engineer, Time, Inc., Stamford, Conn., a 1950 graduate of the University of British Columbia.

James V. Robinson, Group Leader, The Mead Corp., Chillicothe, Ohio, a 1940 graduate of the University of Illinois with a Ph.D. degree.

Vernon C. Robinson, Field Engineer, International Nickel Co., Minneapolis, Minn., a 1938 graduate of the University of Minnesota.

Heinz Rottman, Production Manager, Renker-Belipa, Berlin, Germany, a 1952 graduate of the Technical University of Berlin with a Ph.D. degree.

Robert E. Russell, Technical Supervisor, Eastman Kodak Co., Rochester, N. Y., a 1936 graduate of Union College.

Fritz Schuch, Chief Papermaker, Orient Paper Mills, Orissa, India.

Yukuo Shirane, Chief, Testing Materials Section, Mikuni

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Kenneth M. Shold, Technical Assistant to Kraft Mill Superintendent, Crown Zellerbach Corp., Port Townsend, Wash., a 1947 graduate of the University of Washington.

Helen M. Showronska, Librarian, The Sherwin-Williams Co., Cleveland, Ohio, a 1948 graduate of Western Reserve University.

Robert J. Smallian, Vice-President in Charge of Operations, The Capital Wire Cloth & Mfg. Co. Ltd., Ottawa, Ont., Canada, a 1938 graduate of Queen's University.

Patricia Snyder, Librarian, Owens-Illinois Glass Co., Toledo, Ohio.

Carl V. Spangler, J. F. Pritchard & Co., Pittsburgh 19, Pa., a 1930 graduate of Ohio State University.

Olv Stavrum, Mill Manager, Sande Tresliperi A/S, Sande i Vestfold, Norway, a graduate of Gothenburg Technical Institute.

Kenkichi Tadokoro, Assistant Director, Seaki High Alpha Pulp Mill, Kokoku Rayon & Pulp Co., Minato-ku, Tokyo, Japan, a 1935 graduate of Kyoto University.

Curt Thies, Student, Western Michigan College, Kalamazoo, Mich.

Ernest Tonjes, Chief Engineer, Pioneer Div., The Flintkote Co., Los Angeles, Calif., a 1931 graduate of Cooper Union Institute of Technology.

R. Della Torre, Technical Representative in Italy, National Zetmeelindustrie N. V., Veendam, Holland, a 1945 graduate of the University of Lausanne, Switzerland.

Herman T. Vardeman, Mechanical Engineer, Southland Paper Mills, Inc., Lufkin, Tex., a 1947 graduate of Texas A. & M. College.

Friedrich Vierhapper, Head of Research Dept., Zellwolle A/S, Lenzing, Austria, a 1939 graduate of the University of Vienna.

Andreas von Koppen, Research Officer, Commonwealth Scientific & Industrial Research Organization, Div. of Forest Products, Melbourne, Australia, a 1939 graduate of Forest Academy, Leningrad with a Dr.Ing. degree from the Technical University, Darmstadt, in 1948.

Edward F. Wagner, Technical Director, Witco Chemical Co., New York, N. Y., a 1938 graduate of Illinois Institute of Technology with a Ph.D. degree in 1945.

John C. Williams, Director of Technical Research, Hawley Products Co., St. Charles, Ill., a 1931 graduate of Oberlin College, with a Ph.D. degree from Iowa State College in 1937.

Albert O. Wingender, Technical Sales, Ansul Chemical Co., Marinette, Wis. Attended the University of Wisconsin.

Louis H. Wittenberg, Kraft Mill Superintendent, Canadian International Paper Co., LaTuque, P. Q., Canada, a 1938 graduate of the University of Toronto.

Harry A. Wright, Allis-Chalmers Mfg. Co., W. Allis, Wis., a 1933 graduate of the Carnegie Institute of Technology.

Frank W. Young, Consultant in Pulp and Paper, Medfield, Mass., a 1911 graduate of Stevens Institute of Technology.

TAPPI Notes

Milton R. Bailey is now Executive Vice-President of Bulkley, Dunton Pulp Co., Kalamazoo, Mich.

Fred G. Barber is now Manager of Manufacturing of the Gardner Board & Carton Co., Lockland, Ohio.

John S. Barton is now Manager of Paper Research for the Crown Zellerbach Corp., Camas, Wash.

LeRoy J. Bauer, formerly of Doeskin Products Co., is now Sales Engineer for Bauer Bros. Co., Easthampton, Mass.

David R. Bernhardt, formerly of the Oxford Paper Co., is in the U. S. Army.

Endore A. Berry, Jr., Sales Engineer of Dorr-Oliver, Inc., has been transferred from Oakland, Calif., to Seattle, Wash.

K. R. Bes, formerly of the Institute of Fibers and Fiber Products, is now in the office of the Prime Minister, United Nations, Jerusalem, Israel.

Walter C. Bloomquist is now Manager of Application Engineering for the General Electric Co., 1405 Locust St., Philadelphia, Pa.

John E. Boyle, formerly of Booz, Allen & Hamilton, is now Director of Business Planning, Brown Instrument Div., Minneapolis-Honeywell Regulator Co., Philadelphia, Pa.

William E. Breitenbach, formerly of Rayonier, Inc., is now Executive Vice-President of Alaska Pine & Cellulose Ltd., Vancouver, B. C., Canada.

Thomas F. Butler, formerly of Champion Paper & Fibre Co., is now owner of Holiday Photo Shop, West Palm Beach, Fla.

Philip S. Cade is now Vice-President in Charge of Manufacture for the Harding-Jones Paper Co., Middletown, Ohio.

Gerard Chapman is now Technical Director of the Walloomsac Div., Columbia Box Board Mills, Inc., North Hoosick, N. Y.

Harold Y. Charbonnier is now Manager of the Pulp and Paper Div. of Union Bag & Paper Corp., Savannah, Ga.

John L. Clouse, Sr. is now Technical Assistant to the Mill Manager of the Oxford-Miami Paper Co., West Carrollton, Ohio.

Grant E. Cole, formerly of the Diamond Match Co., is now Assistant Technical Director of Finch, Pruyn & Co., Glens Falls, N. Y.

H. Lance Crosby, formerly of Rayonier, Inc., is now Process Engineering Specialist for Dorr-Oliver, Inc., Stamford, Conn.

Lawrence C. Crowder, formerly of the Rome Kraft Co., is now Project Engineer for the St. Regis Paper Co., Jacksonville, Fla.

William R. Csellak is now Manager of Manufacturing of the Gardner Board & Carton Co., Middletown, Ohio.

Joseph Cutro, formerly of the Black-Clawson Co., is now Plant Engineer of the Otsego Falls Paper Mills, Inc., Otsego, Mich.

Thomas T. Dunn is now Vice-President in Charge of Manufacturing, Union Bag & Paper Corp., Savannah, Ga.

A. E. Harold Fair is now President of the Brown Co., Boston, Mass.

Warren A. Girard, formerly of the Peavey Paper Mills, Inc., is now Mill Manager of the Valentine Pulp & Paper Co., Inc., Lockport, La.

Serge N. Gorbatsevich, formerly student at the New York State College of Forestry, is now a Research Chemist for the Consolidated Water Power & Paper Co., Wisconsin Rapids, Wis.

John R. Guilliams of Wilson & Geo. Meyer & Co., has been transferred from Los Angeles to San Francisco, Calif.

Ronald L. Hamilton, formerly Process Engineer of the Marathon Corp., is now 2nd Lieutenant, U. S. Grand Island, N. Y.

Frederic C. Keeney is now Technical Director of the Pulp Div., Weyerhaeuser Timber Co., Springfield, Ore.

Wm. A. Kraske, formerly with the Columbia Cellulose Co. Ltd., is now in the Technical Development Department of the Celanese Corp. of America, New York, N. Y.

Joseph H. Kuhns is now Chief Engineer of the Wausau Paper Mills Co., Brokaw, Wis.

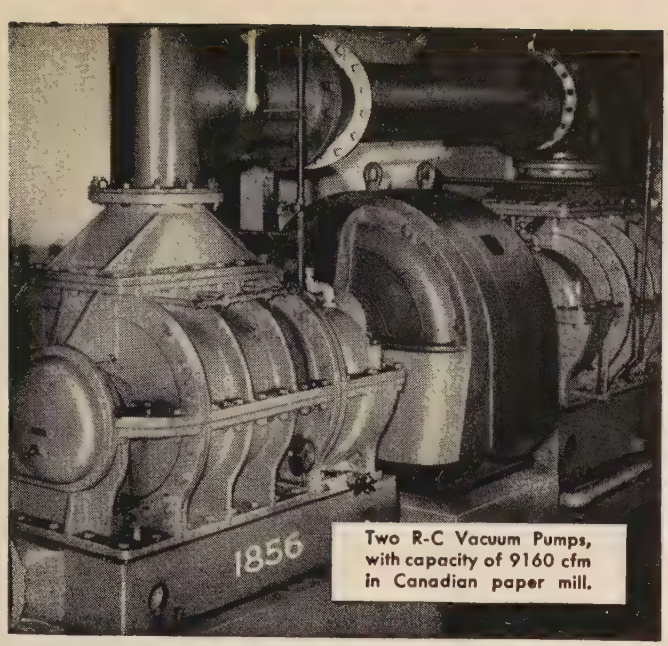
Stephen Kukolich is now Technical Director of the Lee Paper Co., Vicksburg, Mich.

E. L. Lamb is now Director of Manufacturing of the Minnesota & Ontario Paper Co., Minneapolis, Minn.

Clarence Larson is now Vice-President in Charge of Operations of the Minnesota & Ontario Paper Co., Minneapolis, Minn.

A. M. Leth, formerly of Cia de las Fabricas de Papel de San Rafael, is now a Consultant in Mexico City, D. F., Mexico.

Harry F. Lewis has been awarded the Alexander Mitscherlich Medal by the German Association of Pulp and Paper



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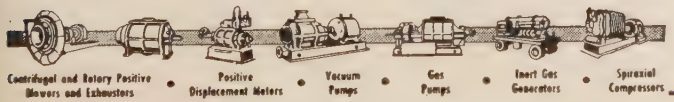

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Engineers and Chemists. The presentation of the medal will be made to Dr. Lewis in September by Georg Jayme of the Technical University of Darmstadt.

James R. Lientz is now Division Manager of the Union Bag & Paper Corp., Savannah, Ga.

Trygve C. Lucken, Jr., formerly of the Riegel Paper Corp., is now in the U. S. Air Force at Sampson Air Force Base.

Jack McKela, formerly of the Atlas Paper Board Co., is now Executive Sales Engineer of the Shartle Bros. Machine Div. of Black-Clawson Co., Middletown, Ohio.

R. Murray MacNaughton, formerly of Alexander Cowan & Sons Ltd., is now Research Chemist for the Wiggins Teape Group Research Organization, Glory Mill, Wooburn Green, Near High Wycomb, Bucks, England.

Albert J. Marchand, formerly of Fraser Paper Ltd., is now in Germany with the U. S. Army.

Charles H. Mahood, Jr., formerly of the Great Northern Paper Co., is now in the U. S. Air Force, Ardmore, Okla.

Philip A. Monaghan of the Jefferson Chemical Co. has been transferred from New York, N. Y., to Houston, Tex.

Henry E. Obermanns is now Manager of the Process and Product Development Section of the Hammermill Paper Co., Erie, Pa.

William Pittam, formerly of the Weyerhaeuser Timber Co., is now Engineer for the Stone & Webster Engineering Corp., Boston, Mass.

Edward L. Powell, formerly Consultant, is now Vice-President and General Manager of Valentine Pulp & Paper Co., Lockport, La.

Roy D. Rivers, formerly of John Inglis, Ltd., is now with Ca. Venezolano de Pulpa y Papel ("Venepal") Puente Soublette, Caracas, Venezuela.

George S. C. Semmens is now Technical Manager of the Australian Paper Makers Ltd., Melbourne, Australia.

Ralph W. Shaffer is now Superintendent of MacAndrews & Forbes Insulating Board Mill, Camden, N. Y.

Leonard F. Swec, formerly of the H. P. Smith Paper Co., is now Development Manager for the Standard Packaging Corp., Jersey City, N. J.

Charles S. Sweitzer, Technical Supervisor of the Gardner Board & Carton Co., has been transferred from Middletown to Lockland, Ohio.

Gerald L. Swope, formerly of the Continental Can Co., is now with Stein, Hall & Co., New York, N. Y.

Edward T. Turner, Jr. is now Superintendent of the Carton Plant of the Gardner Board & Carton Co., Middletown, Ohio.

Roy F. Weston, formerly Sanitary Engineer for the Atlantic Refining Co., is now a partner in the consulting engineering firm of Weston, Eckurfelder and Associates, Newton Square, Pa., specialists in the field of water supply, industrial wastewater treatment, and air pollution control.

Wm. J. White, formerly of the KVP Co. Ltd., is now Assistant to the Vice-President in Charge of Manufacture for the Stevens Paper Mills, Inc., Westfield, Mass.

David F. Williams is now Laboratory Supervisor of the Champion Paper & Fiber Co., Pasadena, Tex.

George A. Zinkel, formerly of the Central Fiber Products Co., is now with Potlatch Forests, Inc., Lewiston, Idaho.

* * *

H. B. Weis, Secretary, has succeeded *George A. Zinkel* as the official corporate representative of the Central Fibre Products Co., Chicago, Ill. in the Technical Association.

John R. Kimberly, President, has succeeded *Cola G. Parker* as the official corporate representative of the Kimberly-Clark Corp., Neenah, Wis., in TAPPI.

Jacques Calloud has succeeded *Charles Calloud* as the official corporate representative of Tauins Rey S/A, Paris, France, in TAPPI.

* * *

P. F. Holstein, Manager of the General Industries Section, Industrial Sales Department, has succeeded *C. P. Walker* as the official representative of the Westinghouse Electric Corp. in the Technical Association.

Industry Notes

PRODUCTION

Paper and board production during May amounted to 2,544,921 tons, according to the Bureau of the Census, Department of Commerce. This is more than 13% above the 2,241,867 tons produced in May a year ago. Paper production amounted to 1,083,413 tons, which is almost 13% above the 962,608 tons produced in May a year ago. The output of paperboard during this month was 1,170,250 tons reflecting an increase of 15% over the production of 1,021,179 tons reported during May, 1954.

Corrugated and Solid Fiber Shipping Containers. Production of container board in the first quarter of 1955 was 14.1% above the comparable period of 1954. Similarly, output of liners increased 13.6% in total as did corrugating materials by 15.7% and chipboard by 11.9%. Compared with the fourth quarter of 1954, board output increased 3.9% with liners up 4.4%, corrugating material up 1.8%, and container chipboard up 10.1%.

Setup Paper Boxes. First quarter 1955 output of setup boxboard was 0.5% above the first quarter 1954 volume. Although the January volume was below the total of January, 1954, February and March output was heavier. Compared with the fourth quarter 1954 output of 181,395 tons, first quarter 1955 volume increased 11,484 tons or 6.3%.

The set-up box industry experienced a record volume of business in the first quarter of 1955. Compared with the previous high of the first quarter 1953, operations were up 2.5%. Compared with the first quarter of 1954, shipments were up 6.8% with gains registered in virtually every major area in the country.

Paper Shipping Sacks. Production of shipping sack paper in the first quarter of 1955 was approximately the same as in the first quarter of 1954; a 0.4% decrease was registered. Whereas production increased in January and February, March production dropped 10.6%. Compared with the fourth quarter of 1954, paper output in the first quarter of 1955 was up 18,314 tons or 9.6%. Of the total, unbleached kraft paper increased 8.4% or 15,049 tons and all other types increased 24.9%.

Paper Bags. First quarter 1955 production of bag paper was 2.7% above the same period of 1954. The increase in total output resulted from a 20.5% gain in March production over March, 1954, as totals for January and February were below the corresponding months of 1954. Unbleached kraft bag paper output increased 1.1% over the first quarter 1954 total as did all other types of bag paper by 28.5%. Compared with the final quarter of 1954, bag paper output in the January-March period was down 4.3%. Of the total, unbleached kraft bag paper decreased 5.8% from the fourth quarter 1954 volume of 231,312 tons. Production of other types of bag paper in the first quarter of 1955, except glassine, greaseproof, and vegetable parchment, increased 22.2% over the fourth quarter 1954 total.

Folding Paper Boxes. Output of folding boxboard in the first quarter of 1955 was 7.8% heavier than in the same period of 1954. Similarly, first quarter production of board exceeded by 50,388 tons, or 8.3% the fourth quarter 1954 total of 606,990 tons.

Paper Milk Containers. Production of paper milk containers in the first quarter of 1955 continued strong with the total approximately 10 to 13% above the first quarter 1954 volume. Also, industry output for the first quarter of 1955 was slightly above the preceding quarter.

Newsprint. Production and shipments of newsprint in North America during June, 1955, amounted to 638,986 tons

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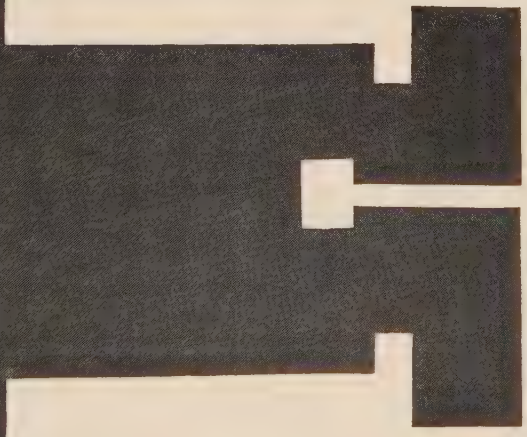

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—an all-time June record—and to 676,794 tons respectively, compared with corresponding totals of 590,031 tons and 622,855 tons in the same month of last year. Output in the United States was 131,212 tons—the largest June volume since 1926—and shipments were 133,370 tons while Canadian (including Newfoundland) production amounted to the record June high of 507,774 tons and shipments to 543,424 tons.

Through the end of June this year United States mills turned out 160,191 tons or 27.8% more newsprint than in the first six months of 1954 while output in Canada also was 119,254 tons or 4.1% greater than in the corresponding period of last year, thus the continental increase totaled 279,445 tons or 8.0%.

Export Growth

In recent years the United States pulp and paper industry, which traditionally has produced for and premised its planning on domestic demand, has shown a growing interest in the expanding opportunities in overseas markets. As a result, exports have risen sharply in recent years as, from 1949 to 1954, foreign sales of wood pulp increased from 122,000 tons to 442,000 tons and of paper, board, and converted products from 372,000 tons to 700,000 tons. Further, there is every indication that the rising standard of living accompanying the industrial recovery of Europe and the increasing economic development in other world areas, will cause the world demand for this industry's products to continue to grow. The limited

U. S. Exports of Wood Pulp, Paper, Paperboard, and Paper Products by Major Markets: 1954 and 1949

(In short tons and by dollar value)

	Total	*Wood pulp*	*Paper*	*Paperboard*	*Converted products*
			Canada		
Quantity					
1949	86,315	35,882	23,880	9,506	17,047
1954	168,522	47,914	30,974	64,897	24,737
Value					
1949	19,404,338	3,824,760	7,036,546	1,925,640	6,617,392
1954	40,371,629	5,546,336	11,298,581	9,807,478	13,719,234
			United Kingdom		
Quantity					
1949	20,351	4,511	927	14,712	201
1954	190,191	107,976	1,166	80,852	197
Value					
1949	2,983,921	794,384	470,480	1,556,128	162,929
1954	26,323,257	15,845,757	417,858	9,912,723	146,919
			Cuba		
Quantity					
1949	36,880	294	20,009	12,029	4,548
1954	79,373	21,586	30,012	19,176	8,599
Value					
1949	8,799,585	40,126	4,934,911	1,532,433	2,292,115
1954	18,355,600	2,915,457	7,465,700	3,325,824	4,648,619
			Venezuela		
Quantity					
1949	19,205	263	7,425	3,433	8,084
1954	56,792	1,381	30,426	7,977	17,008
Value					
1949	6,931,618	25,994	2,295,824	565,249	4,044,551
1954	16,435,508	153,979	6,320,234	1,347,935	8,613,360
			Philippines		
Quantity					
1949	69,397	113	36,509	16,513	16,262
1954	64,194	1,346	40,250	14,094	8,504
Value					
1949	13,149,880	13,469	6,547,234	1,874,331	4,714,846
1954	14,058,491	166,296	8,271,369	2,018,259	3,602,567
			Mexico		
Quantity					
1949	35,381	9,563	17,986	3,891	3,941
1954	54,160	28,883	15,437	4,621	5,219
Value					
1949	7,451,343	1,045,803	4,037,511	641,158	1,726,871
1954	11,815,597	4,223,518	4,270,773	911,043	2,410,263
			South Africa		
Quantity					
1949	47,918	635	8,945	35,993	2,345
1954	64,367	373	18,063	44,838	1,093
Value					
1949	7,174,573	59,782	2,023,489	3,824,556	1,266,746
1954	10,204,638	47,307	3,559,822	5,656,056	941,453
			Colombia		
Quantity					
1949	15,473	528	11,330	1,651	1,964
1954	33,241	8,305	19,961	2,437	2,538
Value					
1949	4,081,834	72,739	2,872,879	286,996	849,220
1954	7,955,641	997,182	4,729,942	605,821	1,622,696

ANACONDA METAL PRODUCTS

Copper, and copper alloyed with zinc, tin, nickel, lead, aluminum, phosphorous, manganese, silicon, tellurium, cadmium and chromium in all combinations that can be wrought into sheets, strips, plates, wire, rods, bars, seamless tubes, drawn and extruded special shapes, and die pressed forgings.

Pulp and Paper Mill Applications

For years, Anaconda Copper and Copper Alloys have been used to solve corrosion and mechanical problems in pulp and paper mills; in many instances through the development of special alloys to provide combinations of qualities not obtainable in standard materials.

Among the Anaconda Products and Metals used extensively in the pulp and paper industries are:

WIRE

Brass shute wire and Phosphor Bronze warp wire for weaving into Fourdrinier screens and cut cloth for cylinder molds. Phosphor Bronze and Silicon Tin Bronze winding wire for cylinder mold construction.

RODS AND BARS

* Everdur, Phosphor Bronze, Naval Brass and other Copper Alloy rods for cylinder mold construction.

* Everdur screws, bolts, nuts, washers and tie rods for wood vat and tank construction, and for most pulp and paper mill fastening requirements.

Phosphor Bronze and special alloy Jordan and Beater Bars.

WELDING RODS

Copper and Copper Alloy welding rods for gas and arc welding.

SHEETS AND PLATES

* Everdur, Brass and Copper sheets and plates for welded and brazed construction of tanks, vats, "save-all" pans, and for lining cylinder vats, and head boxes.

* Reg. U.S. Pat. Off.

PIPE AND TUBES

Red Brass tubes, specially fabricated for Fourdrinier table rolls, felt rolls, guide rolls and other types of paper mill rolls.

Large-diameter, cold-drawn, Seamless Copper Tubes for stock and water lines up to 26″ I.D. in all standard and many special wall thicknesses.

Small-diameter, cold-drawn, Seamless, Copper Tubes for lubricating and air lines and for meters and other types of instrumentation.

Anaconda 85 Red Brass and Copper S.P.S. Pipe for use with threaded fittings. Anaconda Copper Tubes are made in nominal diameters ¼″ to 12″. They are supplied hard drawn and soft annealed in 20-foot straight lengths; and soft in 100-foot coils up to 1″ diameter and 60-foot coils in 1¼″ and 1½″ diameters.

ELECTRICAL CONDUIT

* Everdur Electrical Conduit in Rigid (threaded) and EMT, is listed under Factory Inspection and Label Service Procedure by Underwriters' Laboratories, Inc. This non-rust, corrosion-resistant, high-fatigue-limit material is used in locations where excessive dampness or corrosive fumes are present. 53215

TECHNICAL SERVICE

Corrosion Resistance of copper and copper base alloys to specific corrodents is discussed and tabulated in Anaconda Publication B36, "Corrosion Resistance of Copper and Copper Base Alloys." A free copy will be mailed upon request.

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ability of the traditional pulp and paper producing countries abroad to expand their output much beyond the present level, indicates that there is a strong likelihood that exports by North American mills will steadily increase to meet world demand.

While exports of this industry's products have enjoyed a relatively rapid increase, they represent in general but a small fraction of domestic production and they have been limited to a large extent to countries contiguous to the United States and those which have been closely tied historically to this country.

In the accompanying table, exports for the years 1949 and 1954 for the eight principal markets for United States pulp and paper exports are shown. These countries took 70% of our pulp and paper exports in 1949 and 62% in 1954. In the Western Hemisphere, Canada, Cuba, Venezuela, Mexico, and Colombia were, in the order listed, the major markets. Exports to these countries represented 26% of the total in 1949 and 35% in 1954. The principal increases occurred in wood pulp and board exports, the former increasing from 46,530 tons to 108,069 tons and the latter from 30,510 tons to 99.108 tons.

Indicative of the times and the industrial recovery in Europe is the substantial growth of the United Kingdom as a market, especially for wood pulp and board. In the relatively short period of six years exports of wood pulp increased from 4500 tons to 108,000 tons and of board from 15,000 tons to 81,000 tons.

Africa has been growing as a market over the years and with industrial development rapidly increasing, this continent should offer excellent opportunities for further expansion of the present markets. South Africa, the principal consumer country of this growing continental market, has been a large buyer of our industry's products, especially board, and ranks seventh among our principal markets.

The Far East continues as an important market, but the expansion of the pulp and paper industry in Australia and New Zealand and the resurgence of the Japanese paper industry, will offer greater competition to our products in this area in the immediate future. The Philippines have continued to be one of our major markets over the years, though our exports over the period covered have shown a moderate downward trend.

The trend in most countries of the world is for a gradual lifting of exchange restrictions, currency allocations, import quotas, etc., and, therefore, this industry can look to the expansion of present and the development of new markets.

Pulpwood

Total receipts of pulpwood for the January–April period were 10,353,000 cords, an increase of 1,281,000 cords over the comparable period last year. Domestic receipts increased 1,197,000 cords and imports were 84,000 cords above last year's.

Pulpwood consumption continued high and by the end of April was 10,808,000 cords, an increase of 1,386,000 cords above the comparable period last year.

Wood Pulp

Production of wood pulp in the first four months of this year was 6,713,000 tons based on preliminary Census Bureau data, 826,000 tons more than for the comparable months last year.

Continuing high paper and board production raised total wood pulp consumption for the first four months of this year to 6,915,000 tons, an increase of 735,000 tons above that for the same months in 1954.

Wood pulp imports for the January–April period this year were 677,083 tons an increase of 28,834 tons. Imports from Canada increased from 533,223 to 570,074 tons, while imports from Europe declined from 115,026 tons to 107,009 tons.

Preliminary data on wood pulp exports, show that shipments for the first four months of this year were 214,190 tons, an increase of 129,099 tons above exports for the January–April period last year.

Waste Paper

Total receipts of waste paper for the first four months of this year were 2,825,000 tons, 170,000 tons more than for the comparable months last year.

Paper and board production have been at a record high and this has been reflected in a marked increase in waste paper consumption. For the January–April period consumption was reported at 2,881,000 tons an increase of 209,000 tons above the same period last year.

The present high level of paperboard production and indications of continuing strong demand for all grades will undoubtedly mean a continuation of the strong demand for old corrugated which features the wastepaper industry at present, as well as a healthy demand for all other grades.

Capital Expenditures

Expenditures per employee for new plant and equipment by the paper and paper products industry in the United States amounted to $875 in 1947, $839 in 1954, and will be about $819 in 1955. The average for all industries was $393 in 1947, and is expected to be $387 in 1955.

Source: Federal Reserve Bank of Boston *Monthly Review*, June, 1955.

Sound Analyzer Standard

The American Standards Association, 70 E. 45th St., New York, N. Y., has published American Standard Method for Specifying the Characteristics of Analyzers Used for the Analysis of Sounds and Vibrations, Z24.15-1955. The Standard is available from ASA at 50¢ per copy.

Package Engineering Course

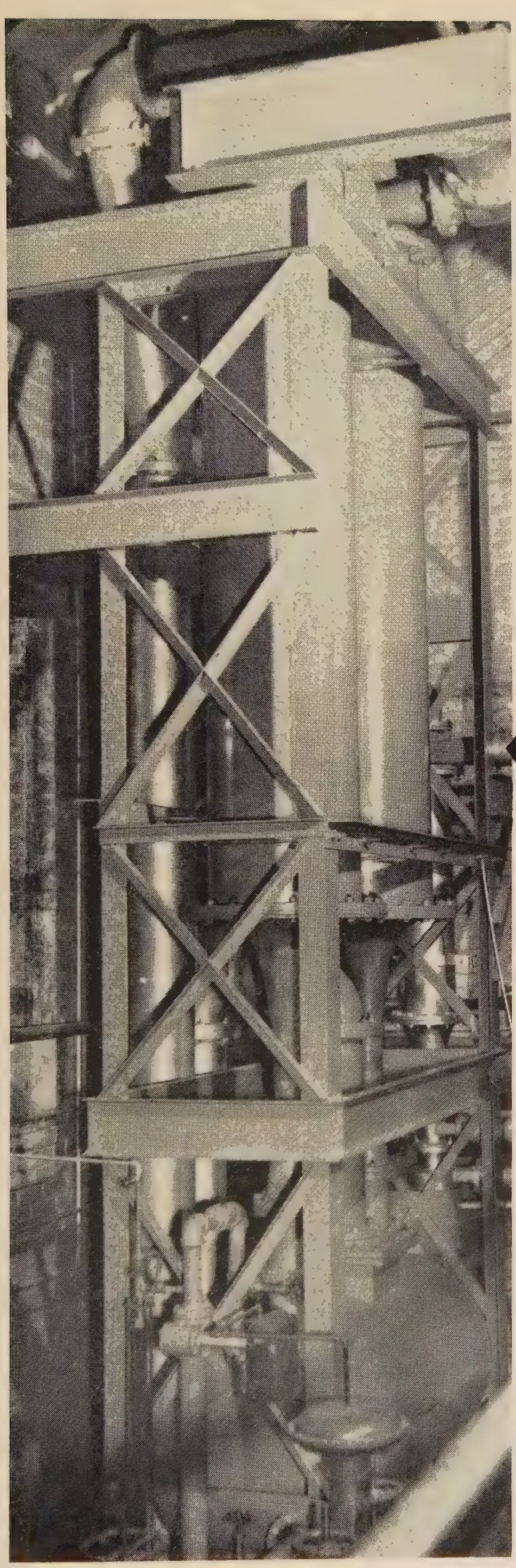
Columbia University, New York, N. Y., will offer a 30-week course in packaging engineering, beginning October 5. Lectures will be given Wednesday nights by 22 lecturers from the packaging field. The first half of the course will cover modern consumer unit styles, flexible packaging and interior packaging of all types for the products of industry and agriculture. The second half will cover types of construction, engineering principles, and materials employed in shipping containers of all kinds.

Tree Gun

C. H. Iffrig, 2434 Annalee Ave., Brentwood 17, Mo., has invented a gun for injecting substances into trees. It is claimed that $2^1/_2$ oz. of debarking chemical, insecticide, preservative, stain or seasoning agent can be injected under the bark of a tree with a single shot. The explosive force lifts the bark and distributes the chemical over an area of 2 sq. ft. or more.

Forest Publications

The Northeastern Forest Experiment Station, Upper Darby, Pa., has published the following bulletins: Forest Statistics for New York Forest District No. 15, Forest Statistics for New York, and How Damage to Balsam Fir Develops After a Spruce Budworm Epidemic. The following *Forest Research Notes* of the Northeastern station have also been issued: No. 45, Relationship of Stump Diameter to D.b.h. for Yellow Birch in the Northeast; No. 46, Relationship of Stump Diameter to D.b.h. for Northern Red Oak in the Northeast; No. 47, Size of Trees Cut in the Northeast for Sawlogs and Pulpwood; No. 48, A Dual-Nozzle System for Mist Blowers; No. 49, Observations Following Wildfire in a Young Stand of Virginia Pine and Hardwoods; No. 50, Estimating Upper Stem and Limb-Wood Volume; No. 51, Use of Sprays to Control the Pales Weevil; and No. 52, Use Ammate in Notches for Deadening Trees Only During the Growth Sea-



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At left: VORVAC installation on newsprint machine. Consolidated Paper Co., Laurentide Division, Grand Mere P. Q., Canada

son. The Southern Forest Experiment Station, New Orleans, La., has published a release on 1954 Pulpwood Production in the South.

Forest Fires

Forest fire fighters were called to an average of 485 fires a day during calendar year 1954 according to United States Department of Agriculture bulletin of June 17, 1955. This represents a total of 176,891 forest fires for the year which injured more than 8.5 million acres of forest resources—timber, water, forage, wildlife, and recreational opportunities. Although the number of fires in 1954 increased 12% over the 154,160 reported for 1953, forest fire fighting agencies are encouraged by two aspects of the 1954 record. The acreage burned decreased, and the number of fires is still under the average for the past 5 years—181,740—despite the fact many areas experienced several years of continuous drought. The total acreage burned in 1954 was 8,832,963 acres as compared to 9,975,750 in 1953.

Great Northern

A 25-ft. Foxboro control panel, graphically portraying white liquor preparation and the operation of two digesters, is one of the outstanding instrumentation features at the new East Millinocket mill of the Great Northern Paper Co.

The result of close cooperation between engineers at Great Northern, Stone & Webster, and The Foxboro Co., the panel was designed to serve as the nerve center of the semichemical pulping plant. Measurements of all important variables are transmitted from process to panel and are indicated, recorded, or controlled as required. The panel also serves as a center for auxiliary controls, such as switches that electrically operate selected control valves and the signal lights that indicate valve positions for the operator's guidance. Here, too, is the intercommunication system used by the digester cook to keep in touch with other operating personnel, and many of the safety interlocks and alarms that protect the personnel.

White Liquor Preparation Panel

The manufacture of white, or cooking, liquor for all digesters is controlled from this 12-ft. panel section, with all process vessels and pertinent flow lines represented by symbols. Instruments are mounted in conjunction with these symbols to give a complete picture of the process.

The first vessel at the far left is the molten sulphur storage tank. Here temperature is controlled to assure suitable sulphur fluidity for the spray burner nozzles. The speed of the sulphur pump may be automatically regulated to maintain the desired strength of the gas leaving the burner, as measured by a sulphur dioxide gas analyzer. The controller, a Model 40 Stabilog, is shown below the tank.

The instrument above the burner symbol, a Model 53-58 Consotrol controller, maintains the correct flow of air to the burner, and a record of exit gas temperature is kept by the circular chart recorder below. Safety interlocks provide automatic sulphur pump shutdown if insufficient air is supplied to the burner or if burner gas temperature is too high.

White liquor results from the reaction of sulphur dioxide gas with a solution of soda ash. A saturated soda ash solution is prepared under controlled temperature conditions in a large slurry tank (pointed roof symbol, left). Both the density of this material and its level in the tank can be seen at a glance on the panel mounted instruments. Since the actual sulphiting requires a soda ash solution of lower concentration, the addition of saturated solution and of water to the sulphiting tanks is automatically controlled. (These sulphiting tanks are represented on the panel by the center two pointed roof symbols.)

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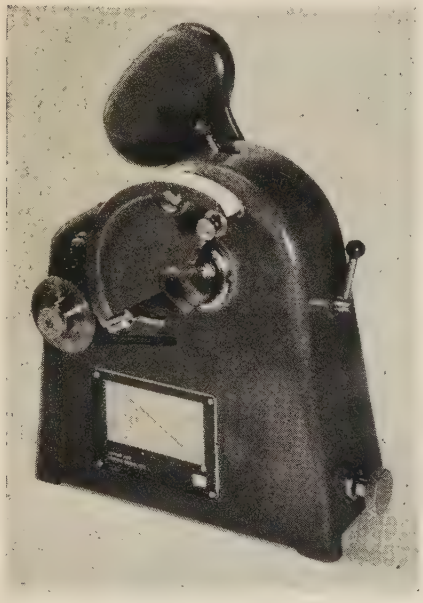
FOR PAPER AND BOARD



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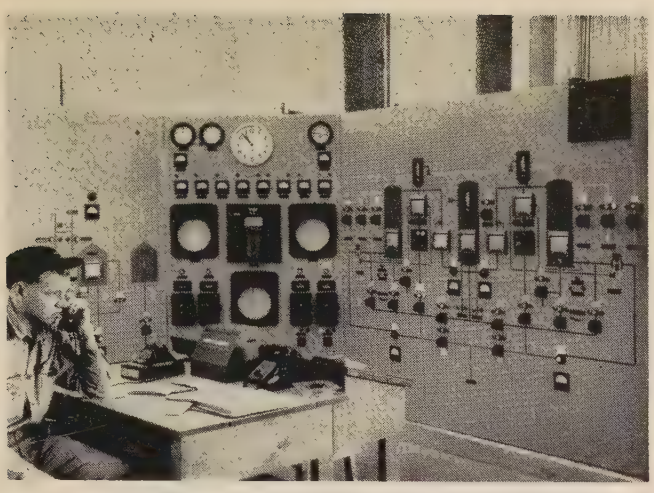


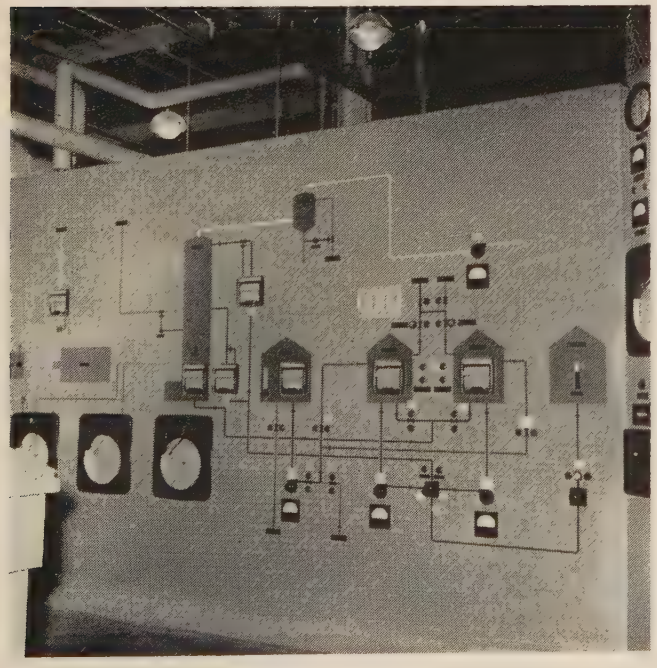
Panel is nerve center of chemical pulping plant. Panel section at right contains digester controls; insert panel is in center. Portion of white liquor preparation panel is at left

In normal operation, flow from either one tank or the other is always being circulated through the absorption tower (tall panel symbol) where reaction gradually converts the soda ash solution to neutral sulphite cooking liquor. Consotrol flow controllers permit the flow of liquor to be distributed as desired between the top and the bottom of the tower. An induced draft fan draws unreacted gases through the condenser where acid traces are removed.

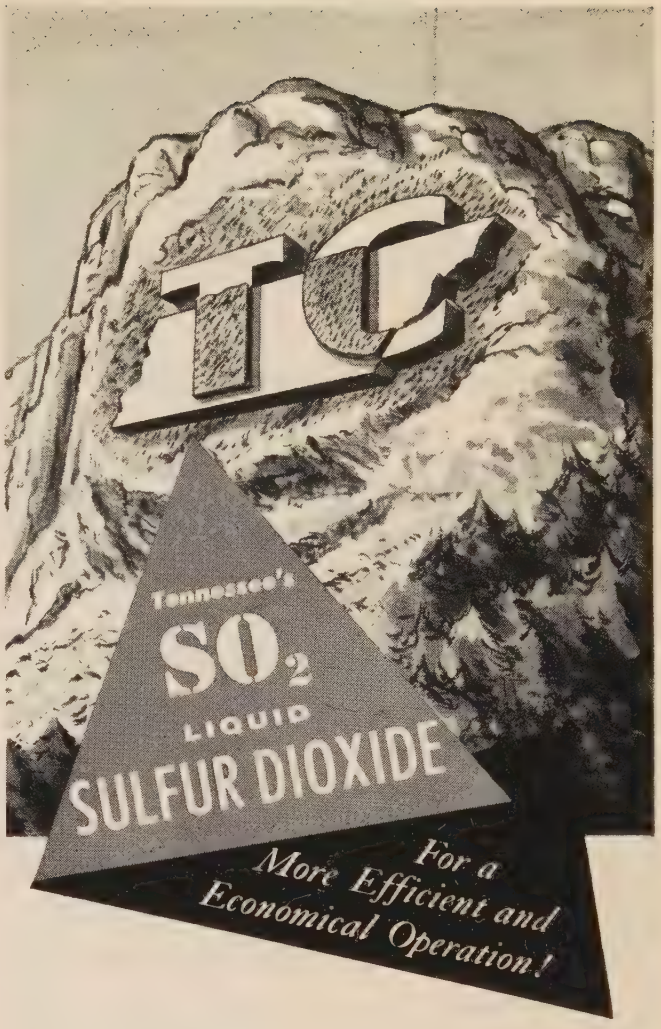
The remaining tower instrument is a Consotrol recorder which measures the pressure drop across the tower, warning the operator of any plugging difficulties. Should the flow of sulphiting liquor to the tower fail, emergency cooling water is automatically added to protect the unit and an alarm light is energized, alerting the operator.

As the sulphiting reaction proceeds, the water lost by evaporation is replenished and a controlled amount of soda ash added to restore the lowered pH. The instrument below the tower symbol, a Multi-Record Dynalog (electronic) recorder, automatically and continuously monitors the pH values at critical process locations—three measurements being recorded in different colored inks on a single circular chart.

When the reaction has been completed, the multiport



Graphic approach—an instrumented flow diagram—is seen in this view of the white liquor preparation panel



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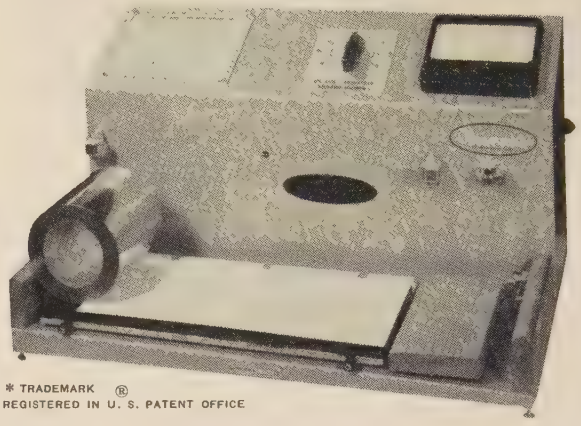

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valve is manually operated, so that the reacted sulphite liquor can be transferred to storage (final pointed roof symbol) and flow from the second sulphiting tank simultaneously circulated through the tower.

The center panel connecting the two graphic sections contains many of the miscellaneous instruments necessary to the operation, such as ammeters, pressure gages, an absolute pressure recorder, a steam flow recorder, a multiple temperature recorder, and a multipoint temperature indicator.

Digester Control Panel

At present, digester controls consist of a single graphic panel section with symbols indicating the two digesters and, between them, the accumulator. As additional digesters are added in the plant, new graphic panels of this design will be added to accommodate the expansion.

Differing from conventional digesters, the equipment at Great Northern is designed to cook entire logs instead of chips. Thus, different methods are employed, requiring corresponding modifications in the control required.

For example, water is used to pad the bottom of the digester to cushion the falling logs. When the digester is full of logs, the water is withdrawn and the logs subjected to high vacuum. Cooking liquor is then transferred to the digester from the accumulator and pressurized with a pump.

Beside each digester in the graphic display is a novel control system which regulates the heating of the digesters. Completely automatic, this system is preset for the rate of temperature rise and holding time desired. The cooking temperature is held at correct value for the length of time set on the timer. At the end of the timed period, the system shuts off the steam and the cycle is completed. Signal lights indicate each phase of the cooking cycle.

Excess pressure is automatically relieved from the digesters to the accumulator during the cook. At the conclusion of a cycle, the liquor is blown back into the accumulator with steam, the digester is pressure relieved, and the logs discharged. Safety interlocks protect the cook, making it impossible to open the digester door unless it is safe to do so. Provision is also made for stopping the motion of any motorized valve instantly, preventing it from going through its full travel if the valve switch is accidentally turned to the wrong position. The withdrawn liquor in the accumulator is fortified with a controlled amount of white liquor and the water loss made up. The digester is then ready to cook the next charge.

The control system and its graphic presentation were carefully planned to provide a maximum degree of automatic operation and the centralization of operating adjustments such as switches, push buttons, and accessory signal lights and ammeters. Start-up results and succeeding operations have proved the success of this objective.

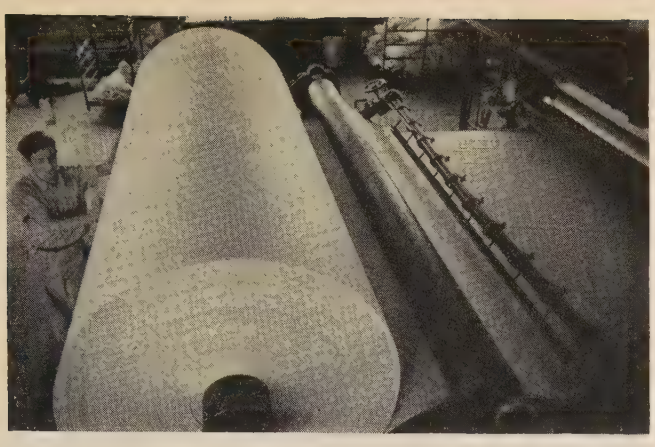
QUEBEC NORTH SHORE

Quebec North Shore Paper Co.'s no. 2 machine at Baie Comeau, Que., had its best monthly production in April, 1955, when it averaged 1925 f.p.m. and 2238 lb. per in. trim per day (32 lb. basis).

BROWN CO.

A. E. Harold Fair has been elected president of Brown Co., Boston, Mass., Laurence F. Whittemore is now chairman of the board, and Stuart W. Skowbo is vice-president and treasurer.

A. E. H. Fair, Brown Co.



The dry end and reel of the 136-in. paper machine at American Israeli Paper Mills Ltd.

American Israeli Paper Mills

American Israeli Paper Mills Ltd., founded by a group of investors in the United States, Latin America, Australia, and Europe, and headed by Joseph M. Mazer, treasurer of the Hudson Pulp & Paper Corp., New York, is now in its second year of operation. Whereas paper production for 1952 and 1953 in Israel showed only 500 tons per year, the tonnage of the paper produced in 1954 was 7500 tons and in the first quarter of 1955 some 4500 tons have already been produced.

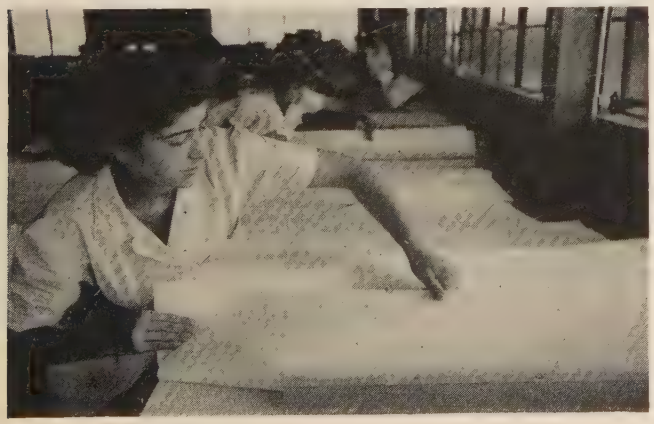
The rated capacity of the mill was originally set at an average of 40 tons per day, based on an estimated consumption in Israel of some 12,000 tons per year of writing and printing paper, multi-wall kraft, other kraft, and sulphite papers. Actual annual consumption in these grades of paper appears to be closer to 15,000 tons.

To meet this increased demand, the Israel mill has brought up its rated capacity to 50 tons average per day, and is exceeding this rate daily. The installation of additional stock preparation equipment will be completed in July and will increase the daily average to 75 tons.

The employment of locally trained personnel has proved to be successful in operating jobs, but overseas supervisory personnel will be needed for some time. Robert W. Zion, a Hudson Pulp & Paper Corp. executive, general manager of American Israeli Paper Mills Ltd., has been in Israel since the first stage of construction.

Expansion plans include the addition of a second paper machine to make papers under basic weight of 50 grams per sq. m. This will provide citrus wrap, manifold, toilet paper, paper napkins, and the lightweight papers.

After only 15 months of operation, the Israel mill is already financially in the black and on March 31, 1955, paid its first interim dividend for the first quarter of 1955.



Excellent results have been achieved by training local personnel with the aid of foreign personnel in Israel

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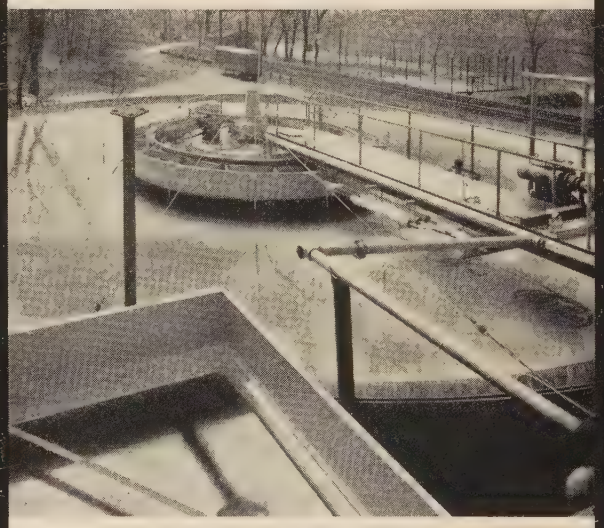
WHITE WATER



Clear, clean water that you can re-use in the mill or return to stream is economically produced with N-Sol coagulant aid. N-Sol, activated silica sol, plus alum or acid salts enmeshes finely divided impurities into fast forming flocs, which settle or are removed by filtration or flotation.

Mills using the N-Sol Process report solid contents of white water reduced from 10-20 pounds per thousand gallons to ½ pound or less per thousand gallons. Ask for useful file #52—Treatment of Raw and Waste Waters.

N-Sol is prepared conveniently in your plant with "N" sodium silicate and reactant chemical. No charge for license under N-Sol Patents.

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In the past year, more than
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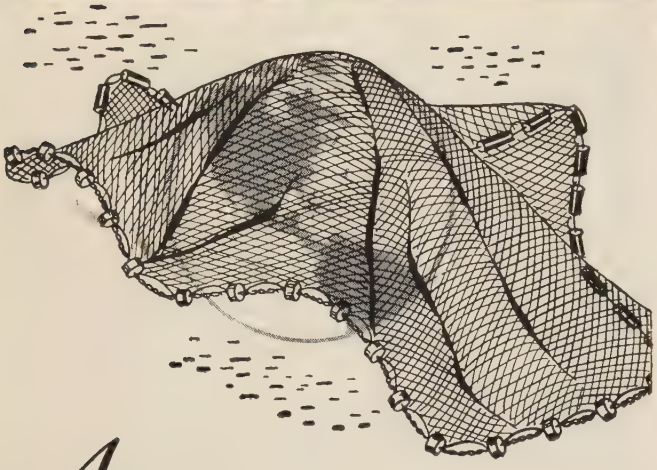

All over the world there is a network of Scott Testers* speaking a universal language, enabling you to exchange information in exact and identical terms on many physical test evaluations essential in the purchase, manufacture and use of paper and paper products, textiles, plastic film, etc.
In 51 countries, government bureaus, laboratories and industry rely with confidence on Scott equipment and test methods as the accepted standard of the world for complying with ASTM, TAPPI, Government and ISO specifications.

We manufacture a wide selection of light capacity recording testers for tensile strength, elongation, tear adhesion, lamination bond.

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REPRESENTATIVES IN FOREIGN COUNTRIES

Standard of the World

J. R. Lientz (center), new head of the Savannah plant of Union Bag & Paper Corp., receives the congratulations of T. T. Dunn, vice-president in charge of manufacturing. Looking on at right is H. Y. Charbonnier, new head of the company's Pulp and Paper Division

UNION BAG

J. R. Lientz has been appointed manager of Union Bag & Paper Corp.'s Savannah operations, replacing T. T. Dunn, who is now vice-president in charge of manufacturing. H. Y. Charbonnier is named manager of the plant's Pulp and Paper Div. G. W. E. Nicholson, formerly vice-president in charge of manufacturing, is now executive vice-president in charge of future planning and expansion.

RAYONIER

W. E. Breitenbach has been named executive vice-president of Alaska Pine & Cellulose Ltd., Vancouver, B. C.

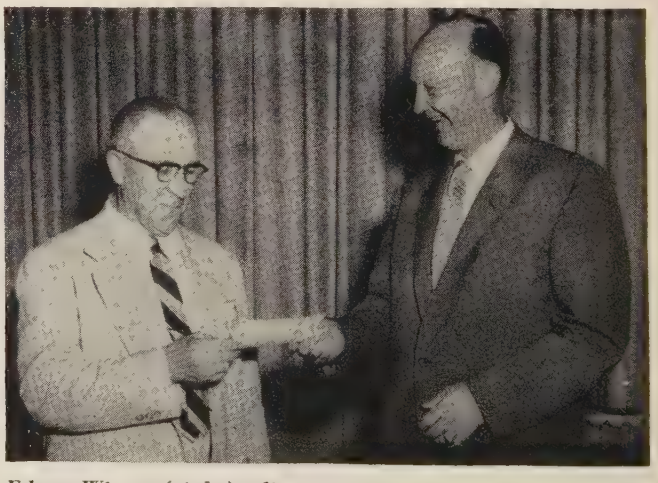
William A. Cawley, Thomas A. Mostyn, and Stig G. Palmgren have joined the engineering department of Rayonier.

DIXIE CUP

The Dixie Cup Co., Easton, Pa., recently became the first associate member of the Pulp and Paper Foundation in North Carolina State College's School of Forestry.

MANDO

Minnesota and Ontario Paper Co. has contracted with



Edgar Winne (right), director of purchases for the Dixie Cup Co., of Easton, Pa., is shown presenting a $500 check for the first associate membership in the Pulp and Paper Foundation, Inc., of the North Carolina State College School of Forestry to Prof. C. E. Libby, head of the Curriculum in Pulp and Paper Technology at North Carolina State

Beloit Iron Works for delivery of a new 276-in. high speed newsprint machine to its Kenora, Ont., mill by the end of 1956. The machine will have a General Electric drive.

Hadlai A. Hull, Mando's secretary and treasurer, led an executive development workshop seminar of the American Management Association at Colgate University recently.

Anglo

The Pulp and Paper Research Institute of Canada has announced the award of the 1955–56 Anglo Paper Research Fellowship to Ross M. Screaton of Winnipeg. This Fellowship was established at the Institute in 1951 by the Development Dept. of Anglo-Canadian Pulp and Paper Mills, Anglo-Newfoundland Development Co., Gaspesia Sulphite Co., and Dryden Paper Co., to stimulate fundamental research primarily on the physical chemistry of lignosulphonates and other constituents of spent pulping liquors.

Scott

The installation of a new wood preparation plant and supporting equipment at the Anacortes, Wash., mill of the Coos Bay Pulp Corp. opens new avenues for the use of substantial quantities of alderwood in the manufacture of bleached sulphite pulp.

This major expansion program was started in February of this year and provides for the handling of alder either by truck or by freight car delivery to the mill. The new wood plant has been erected on ground adjacent to the existing pulp mill.

In addition to the wood preparation equipment, new construction also provides facilities for the improved purification of pulp. Stock and caustic soda storage tanks, together with a new building to house the equipment, have been installed.

Of special interest in connection with this new operation will be the operation of two mechanical barkers especially constructed for the peeling of logs. One of these barkers has been operating at the mill on a trial basis for a number of months. Logs are carried through the barker on trunnion wheels which rotate the log. The bark is removed by side heads with angled teeth. Rotating wire brushes located behind the heads, remove the layers of bark.

Other equipment installed in the new debarking plant includes a 112-in. log chipper, conveyors, and chip feeders. Auxiliary equipment and construction include a truck unloading ramp, wood storage areas, railroad track spur, and large crane for the handling of wood.

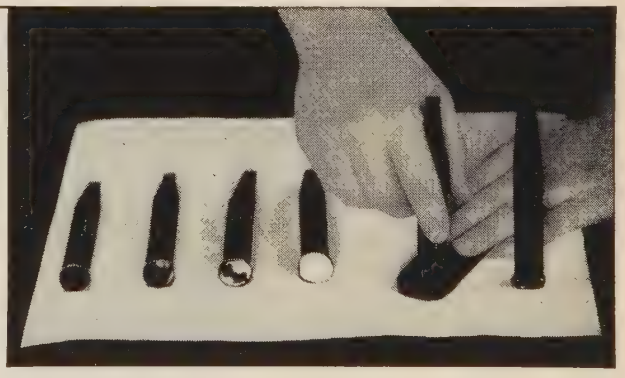
The Coos Bay Pulp Corp. is a wholly owned subsidiary of Scott Paper Co. The major portion of the plant's production will be shipped to the new Scott paper mill at Everett, Wash.

Hudson

The acquisition of the multiwall bag manufacturing business of Hammond Bag & Paper Co. of Wellsburg, W. Va., by Hudson Pulp & Paper Corp. of New York, N. Y., in exchange for shares of Class A Common Stock of Hudson was officially announced recently by William Mazer, president of Hudson. Hammond plants are located at Wellsburg, W. Va., Pine Bluff, Ark., and Charlotte, N. C. Hammond will operate as a separate division with the same executive sales and employee personnel and sales operations and services will as heretofore be conducted under the Hammond name.

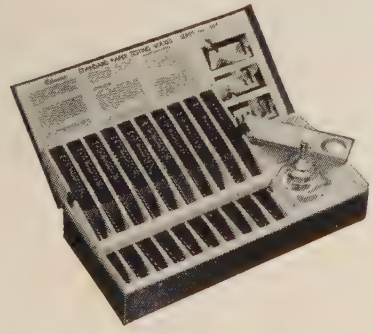
The installation of a nuclear scanning device at Hudson's Palatka, Fla., mill was made recently. The scanner will continuously observe and regulate the quality of every foot of the company's kraft paper. The nuclear device, is the largest

"Laboratory in a box" pre-tests printing papers



You don't have to wait until a job is on the press to check the quality of the paper. DENNISON STANDARD PAPER TESTING WAXES help cut down costly errors and delays by evaluating the surface strength of the sheet *in advance*. This compact kit gives you all you need to evaluate the degree of sizing, the liability to pick, and the type of failure characteristic of the sheet.

DENNISON STANDARD PAPER TESTING WAXES are prepared under technical supervision with rigid standards of accuracy to insure dependable testing. The complete set contains eighteen sticks of waxes with all accessories. The coated paper series contains twelve sticks plus accessories.



The cost of a complete set of DENNISON STANDARD PAPER WAXES is $30.00, Coated Paper Series (Waxes 3A to 14A) costs $24.00. Refill supplies are always available. Instructions included in each kit. Testing method approved by the Technical Association of The Pulp and Paper Industry as Standard Method T459m-48.

Dennison

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PLEASE SEND ☐ Free pamphlet with more information.

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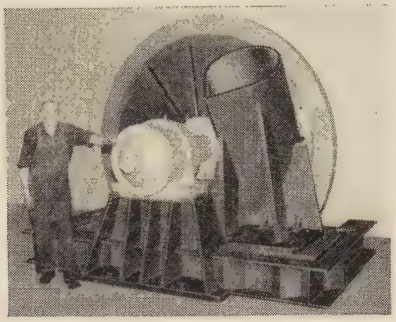
with Carthage Log Barkers, Log Splitters, Log Chippers, Slab Chippers, Chip Screens



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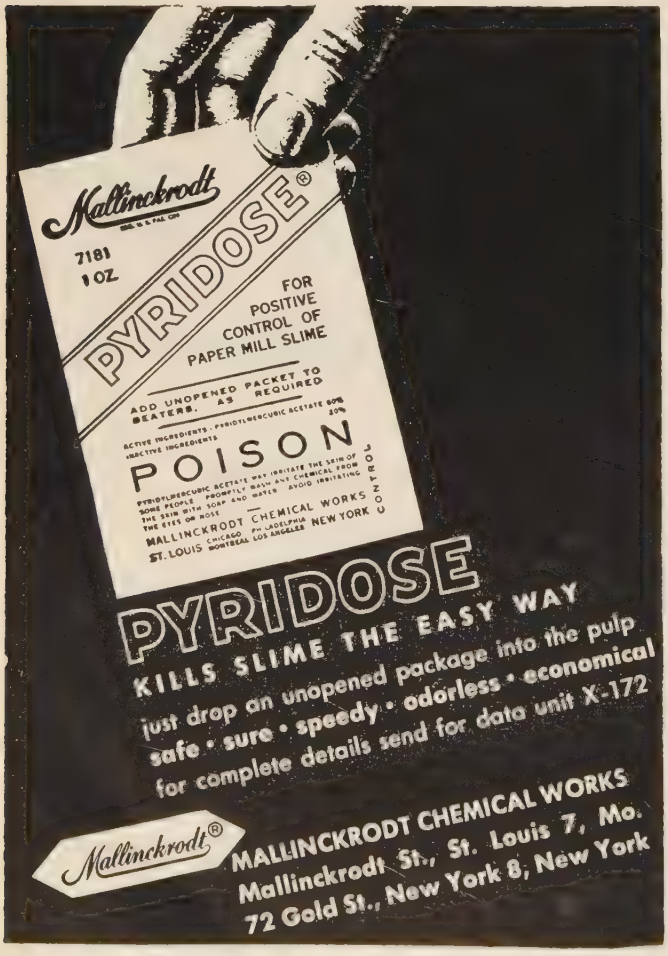
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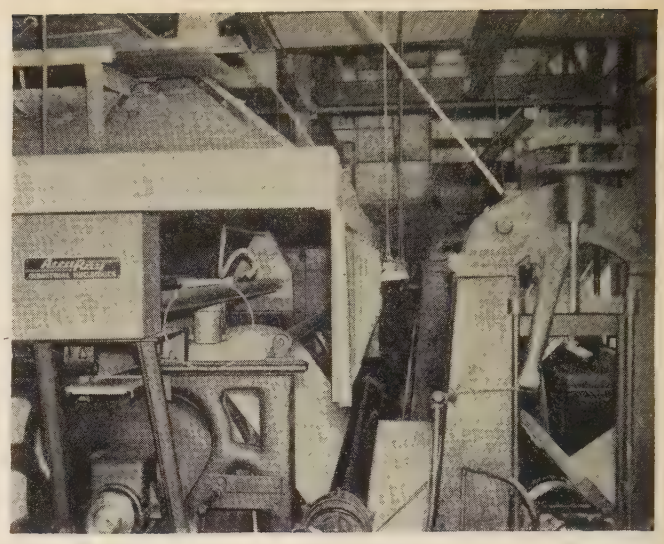


New AccuRay nuclear scanning device installed at Hudson's Palatka, Fla., mill

ever installed in a kraft paper mill, and will insure the production of paper with a uniformity of basis weight never before possible, even with the most skilled papermaking personnel.

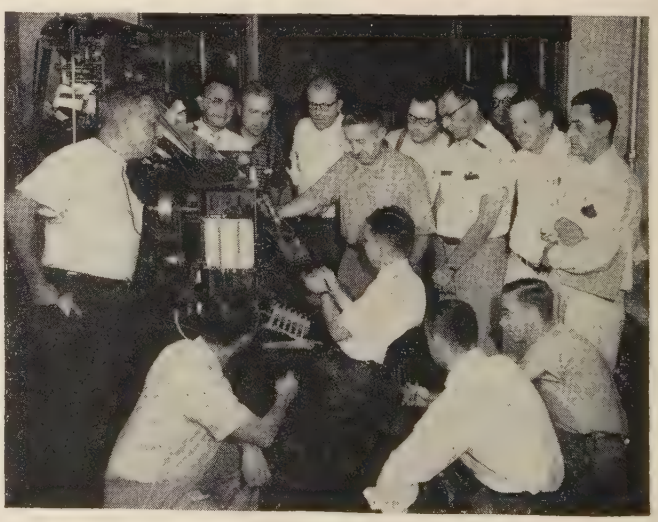
Sweeping back and forth across the papermaking machine, the nuclear scanner's beta rays measure the precise basis weight of the paper and an electronic integrator automatically regulates and controls the flow of pulp fed to the machine. It is expected that the nuclear scanner will regulate the basis weight to a variance of less than 2%, as compared with the commercially acceptable 5%.

RIEGEL

The first commercial run of synthetic paper made wholly from nylon fiber was produced recently by Riegel Paper Corp., New York, N. Y.

The synthetic nylon paper is almost impossible to tear by hand and is many times stronger than paper made with rags or wood pulp. In addition, it is highly resistant to chemical attack, absorbs very little moisture, and resists the action of molds, bacteria, and light.

The high strength of the nylon paper suggests its use in such applications as heavy-duty bags. Its resistance to



Salesmen and executives of the Riegel Paper Corp. were back in school for a short course in printing at Carnegie Institute of Technology. Inspecting the Pittsburgh school's new Fotosetter are, front l. to r.: W. F. Parkes, J. A. Parry, S. R. Dowst (Union Carbide & Carbon Co.), and P. O. Fallon. In the rear of the Fotosetter are, l. to r.: A. F. Klina, A. L. M. Bixler, W. A. Schenck, C. E. Werner, Thomas Felker, T. H. Rutt, Professor R. E. Alden, W. M. Dunn, and D. V. Rossi

chemical attack would be useful in filtration of corrosive liquids and packaging chemicals. The stability of the paper to moisture indicates possible use in map and tracing papers and for important records and documents where permanence is necessary.

At present, the cost of making paper from nylon is considerably higher than from rag or wood pulps. However, costs can be expected to decrease as production increases.

Kimberly-Clark

Kimberly-Clark, headquarters Neenah, Wis., one of the largest U. S. makers of diversified paper products, uses its Memphis, Tenn., facilities for the production of wadding and its conversion into Kotex pads, Kleenex tissue, and Delsey, a toilet tissue. The term wadding is often used as a synonym for highly absorbent creped tissue paper and the Memphis plant may be called a wadding mill.

It is one of the largest K-C producers of the products mentioned. Its annual production of Kotex alone may reach 1 billion pads to which should be added millions of boxes of Kleenex and rolls of Delsey. Thirty-four thousand bales of cotton are needed annually for Kotex gauze, made by two outside mills devoted exclusively to production of this covering material. The Memphis plant uses annually about 500 million yd. of 7-in.-wide gauze. Seventy-three thousand tons of sulphite and sulphate pulps are needed to make the famous-name products of the Memphis mill. Wadding-manufacturing departments work around-the-clock, 7 days per week, and their output is passed to the converting department, which works around-the-clock for 5 days per week. Every day's production calls for the use of 32 freight cars to transport products to distribution points. Distribution is made by the International Cellucotton Products Co., headquarters at Chicago. This concern now offers yellow and pink Kleenex, in addition to the well-known white variety. Delsey is made in white, blue, green, yellow, and pink colors. On June 22, directors of International Cellucotton Products Co. and Kimberly-Clark approved plans for complete integration of the two companies to be presented to stockholders in August. After consolidation joint activities will be conducted by Kimberly-Clark.

The creped wadding products of K-C resulted from the development of a cotton-wadding substitute during World War I. K-C creped wadding was then used as surgical dressing. Kotex was the first wadding product made for retail sale. Kleenex and many other creped wadding products followed.

Memphis is one of four K-C mills in United States and Canada that make cellulose wadding, from which Kotex napkins, Kleenex tissue, and other creped wadding products are made. Production from all K-C mills makes this concern the worlds largest single manufacture of sanitary pads. In the United States such pads are used by over 40 million females. Latest figures on the sale of these pads show that about $131 million worth are purchased annually. In an average year the nation spends about $126 million for facial tissues and $177 million for toilet tissue.

Creped wadding products are made by K-C to precise specifications, based on accurate tests for all characteristics. Kotex, for instance, is not merely a multiple-tissue pad covered with gauze. The pad is composed of 13 parts including creped wadding, fluff (blown tissue floc) lightly waxed very thin wadding, combed-cotton webbing and others. When formed into a pad and covered with gauze the pad must possess high absorbing ability. Rigid tests are performed on the pads to assure high quality standards, not only with regard to absorbency, but also a number of other characteristics. These are supplemented by still more testing by K-C's research and development staff. In pad manufacture precise amounts of sulphate and sulphite pulps must be used, and the creping performed as the tissue leaves the Yankee must be done to obtain a precise amount of wad-

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1 This is a preweighed unit... eliminates weighing errors

2 Control is flexible because of small size tablets

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2,000 tablets to a carton
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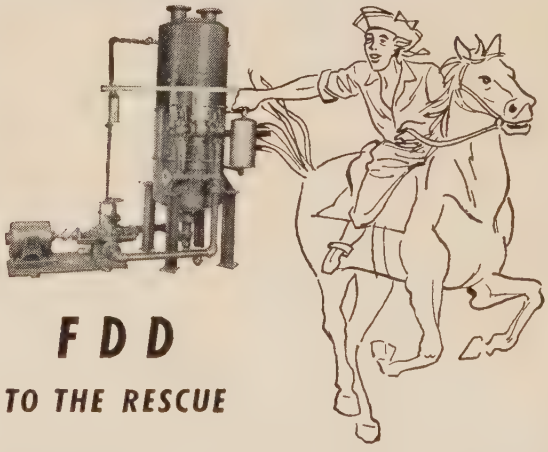

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Every paper machine builder in the land recognizes the incompleteness of his dryer section without Fulton Dryer Drainage. That's why almost every machine built in recent years has included FDD to improve dryer performance.

That's why hundreds of older machines—even small ones—have also installed FDD. That's why close to 1000 Fulton systems have been installed to date.

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Regardless of the age or size of your paper machine, a Fulton Dryer Drainage system would make you money.

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DAYTON, OHIO
A subsidiary of J. O. Ross Engineering Corporation

ing per unit area. Tests also are made for softness and other physical characteristics. Kleenex must pass tests for softness, smoothness, color, limpness, and for tensile strength. Delsey tissue is of the same grade as Kleenex.

Kimberly-Clark has been a paper manufacturer for 83 years. It has been said that the corporation during its life so far has discarded more paper machines, and replaced them with new ones, than any other paper maker in the world. Two small town storekeepers and two of their friends started the business, which now sells $177 million worth of products annually. Its wadding tonnage now exceeds 200,000, its printing paper tonnage approximates 275,000, its newsprint manufacturing associates turn out 322,000 tons of newsprint, with additional large amounts of other papers and pulp. Here's the K-C story.

John A. Kimberly, 34-year-old owner of a general store at Neenah, Wis., and Charles B. Clark, 28-year-old partner in a hardware store, also at Neenah, pooled their cash resources, obtained money from two other men until they had $30,000. This became the capital of Kimberly, Clark & Co., formed on March 26, 1872 for the purpose of erecting a rag-base newsprint mill, called the Globe mill. It not only became a successful competitor of the town's other paper mill—Smith and Van Ostrand—but earned enough money to buy this mill in 1874. Four years later the company built a mill at Appleton, Wis., for the Atlas Paper Co. Atlas made manila paper with a mixture of jute and groundwood pulps. In later years Messrs. Kimberly and Clark bought the Atlas mill and also a flour mill in the same city. Kimberly, Clark & Co. not only produced flour but also built a paper mill, which made the fourth under company ownership.

In 1881 the company bought the Vulcan book and printing paper mill at Appleton and the following year a groundwood pulp mill at Appleton was purchased. Two more Neenah flour mills were bought in 1884 and razed so a rag newsprint mill could be erected on the property. A few months later the Neenah mill was torn down and replaced with a 12-ton-per-day, book-paper mill. By this time, Kimberly, Clark & Co., with a daily production of 70 tons of newsprint, wrapping, and book papers, was considered to be one of the large papermakers in the United States. Even so, however, expansion continued, but a separate corporation—Telulah Paper Co., Appleton, was formed to accomplish it. Telulah built a two-machine, groundwood-newsprint mill of 20 tons per day capacity. The Atlas wrapping paper mill was rebuilt in 1888, after a fire, to produce more paper—32 tons per day. Next expansion, in 1889, was the erection of a new mill—25 tons of groundwood, 30 tons of sulphite pulp, and 10 tons of straw wrapping paper per day. It was built in the new town of Kimberly, a few miles from Appleton. Two years later a 30-ton-per-day newsprint mill was built at Kimberly and in the same year the company acquired an interest in bond and ledger-paper mill at DePere. Charles B. Clark, who had been elected to Congress in the late 1800's, died in 1891.

Another mill, the company's eleventh, was bought in 1897 and some existing ones were sold, rebuilt or expanded in later years. In 1906 Kimberly, Clark & Co. was incorporated as Kimberly-Clark Co. In 1917 creped wadding production started in the Globe mill, the first owned by the company. Creped wadding was used in place of cotton surgical dressings during World War I.

In 1920 a book paper mill was erected at Niagara Falls, N. Y., but another important step that year was the development and introduction of sanitary pads, branded Kotex. This product was sold to drug stores and other retail outlets by Cellucotton Products Co. of Neenah, a separate advertising and sales organization. In 1924, another creped wadding product, Sanek, a strip used by barber and beauty shops, was introduced and this was immediately followed by Kleenex facial tissues. Kotex pads and Kleenex tissue, made by Kimberly-Clark, were sold by the Cellucotton Products Co., which, in 1927, changed its name to International Cellucotton Products Co., and became a separate organization. One year later, Kimberly-Clark changed its name to Kimberly-Clark Corp. and its stock was offered for public sale.

During the years 1917 to 1946 Kimberly-Clark introduced other creped wadding products, increased the capacity of a number of mills, purchased others and also built some in the United States and Canada. These added facilities made newsprint, wallpaper, creped wadding, and other products. The company also acquired forest reserves and chemical plants. In 1947 the Memphis plant was purchased and converted into a mill that made creped wadding and converted it into Kotex, Kleenex (also Pocket-Pack), and Delsey, a toilet tissue.

There followed the construction of a sulphate pulp mill at Terrace Bay, Canada and the purchase of a mill at Munising, Mich., to produce sulphite pulp, bond paper, impregnated stock for shelving and other uses, and speciality papers. Now under construction is a mill at Fullerton, Calif. When this is completed Kimberly-Clark will have 10 mills and converting plants.

The Memphis mill receives bleached sulphate and unbleached sulphite pulps in 400-lb. bales. Sometimes 2.5-foot-square sheets are received. Sulphate pulp bales are conveyed to 2-ton-capacity Shartle Hydrapulpers. This machine breaks up the pulp into its fibers, mixes it with water to form a highly fluid mass in much the same way as a beater. Sulphate pulp-water mixture is passed to agitated dump chests.

Sulphite pulp bales are conveyed to a 1-ton-capacity Vortex beater, made by E. D. Jones & Sons Co., Pittsfield, Mass. Liquid chlorine and water are added to the beater charge. After the chlorine has bleached the pulp, now dispersed in a large volume of water, it is pumped to a retention tower, then to a vacuum-type screen washer. Water is added to the washer feed and this together with the vacuum tends to remove all chemicals and impurities. As pulp mixture leaves the washer it is passed to a dump chest on floor below. The flow of material into and out of the chest is continual.

One of the most important steps in manufacture occurs after the pulp leaves the dump chests. Both pulps are pumped through separate pipes to flow meters that control the ratio of sulphate to sulphite pulp mixture. At this point the water to pulp ratio is about 99.5 to 1. The sulphate-sulphite mixture flows by gravity to a stuff box, or chamber, from which the pump mixture is pumped to high-pressure inlets feeding a fourdrinier wire, on which the tissue is formed into a continuous web. Free water drainage through the wire, plus surface tension of the table rolls over which the wire is passed, removes most of the water and leaves the pulp in the form of a wet tissue on the wire surface. The press section of the paper machines mechanically removes more water. The Yankee drier finally dries the tissue.

The name Yankee, which refers to a single-cylinder drier, did not originate in the United States. The original single-cylinder paper drier, invented in 1829 by Jacob Oeschelhauser, a German, was called the "Flying Dutchman" by American papermakers. When, however, American-made driers of this type were shipped into Germany after 1895, papermakers there called it the Yankee.

The driers of the four Beloit-made, fourdrinier-Yankee paper machines in the Memphis plant are about 12 ft. in diam., are mounted on SKF spherical roller bearings of about 27.56 in. diam. Before the wadding leaves the Yankee, it is creped by a doctor blade. Creped wadding is passed to a calender, then slit and rewound.

Rolls are moved by overhead conveyor to the converting department. Wadding for Kleenex and Delsey is similar but Kotex requires a number of different types and grades.

Converting machines are of K-C design and nearly all are automatic. The Kleenex machines are fed two rolls of wadding. Machines cut the tissue to proper length, fold two sheets at a time and arrange them in units of 400 or 200 double

sheets, depending on the size of the box into which they will be packaged. Kimberly-Clark patented the machine and the method of folding and stacking the sheets so that removal of one pair automatically permits the next pair to be pulled through the slit in the box. Pocket-Pack machines also are automatic, including the glassine wrapping of the Kleenex sheets that form the unit.

Kotex machines are more complicated than those making Kleenex packages. They combine a number of rolls of various components that make up the pad and wrap it in gauze. The gauze is automatically folded and fed and wrapped around the formed pads. Automatic machines count the pads.

Falls Paper and Power

Falls Paper and Power Co., Oconto Falls, Wis., is building an impermeable lagoon for controlling stream pollution. Periodical surveys of the Oconto River are made in cooperation with the Sulphite Pulp Manufacturers' Research League to determine the effect of the various pollution control measures which are being undertaken.

C-Z

A new development fusing a smooth paintable plastic surface onto plywood was announced recently by Crown Zellerbach Corp. The plastic is called "CreZon" and is expected to make a revolutionary change in the acceptance of plywood as a building material for outside construction.

Simultaneously, C-Z announced that the installation of extruder equipment in its plant in North Portland, Oreg., has recently been completed. The firm is one of the first West Coast producers of polyethylene-coated papers, a high performance packaging material.

Polyethylene-coated papers are essentially a film of polyethylene bonded to one or both sides of a sheet of paper, any type from tissue to heavy board. It is impervious to water, remains tough and flexible even at very high or low temperatures and provides a vapor barrier under all conditions of use. Exceptionally useful for food packaging, polyethylene-coated paper is also used in the packaging of industrial chemicals, machinery, and other items.

CreZon, made from wood fiber and tough phenolic resin, is the result of several years of research, experiments, and tests. This tough overlay is supplied to plywood mills in rolls. At the mills the CreZon is bonded to plywood under intense heat and pressure—so strongly that the CreZon and plywood become one and can never be separated.

In the past, the use of plywood was relatively confined to interior applications because plywood could not withstand severe weather conditions. Now, due to CreZon's resistance to moisture, heat, cold, and fungus growth, plywood may become a basic exterior building material.

Accelerated weathering tests show that CreZon fused plywood will not check when painted even under extreme weathering conditions. The new building material can be worked easily. It saws to a smooth edge, no splinter or splitting. The tough phenolic resin holds the fiber of the wood firm and tight for planing, jointing, shaping, grooving, or routing. Grain raise is completely eliminated, which means that paint will go on easier, even without priming, and last far longer than on ordinary plywood.

C-Z has reorganized its Control Research Dept. at Camas, Wash., under W. W. Moyer, director of research. W. M. Hearon has been named general manager of the newly created Chemical Products Div., and also takes over part of the Central Research Dept. organization. Mr. Hearon will be responsible for creative research on ideas for new products from pulping wastes and their production and sales when proved commercially feasible in pilot plants.

A pilot plant is to be built at Camas to produce 2 million lb. annually of dimethyl sulphide from kraft liquors.

In expanding its research into the chemical products field the company has three objectives: to create a new type in-

Chemical Pulping Processes

Chemipulp's high degree of chemical, mechanical and physical control over materials and operations results in maximum plant output, high pulp quality, and low operating costs.

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Mead

NSSC Recovery

The Heald Div. of The Mead Corp. will install a neutral sulphite recovery plant to reduce river pollution at the mill located in the Lower Basin at a cost well in excess of $1,000,000.

The recovery process to be used has been developed by the Research and Development Dept., and is a result of extensive research and pilot plant operations which have been carried on for a number of years. The Lynchburg installation will be the first large commercial-size plant to use the new Mead patented process in this country.

Recognition of the stream pollution problem some years ago resulted in Mead's long range stream improvement program. A part of the program has been the experimental work on treating the semichemical waste from the Lynchburg pulping operation. Recognition of the objectives of the State Water Control Board caused the company to intensify its efforts to find a satisfactory process.

The recovery plant consists mainly of equipment for removing waste material now discharged into the James River and converting it into usable chemicals. The greater percentage of the waste from the plant comes from the pulping operation. With the new recovery plant the waste now going to the river will be washed from the pulp and concentrated in evaporators to a point where it can be burned in a furnace. The ash resulting from the burning operation will be converted to chemicals suitable for reuse in the pulp mill operation.

The company does not at present have plans to increase production of its principal products, corrugating board and paperboard specialities. The new equipment, however, is being designed to handle waste approximately 65% greater than that now coming from the mill. At peak volumes the new Mead process is expected to remove approximately 60 to 70% of the harmful solids and organic material from the waste.

Engineering is now going ahead under the direction of the division engineer, W. P. Guenther. Construction and installation, which will also be handled by local personnel, will begin shortly after the first of the year. It is hoped the new plant will be placed in operation by the end of 1956.

The company has received excellent cooperation from the Virginia State Water Control Board and its staff. They have had a full understanding of the unique problem in bringing about a reduction in the mill's waste discharge to the river and have given it sympathetic consideration and made every effort to help in finding a solution.

While the cost of research, development, construction, and installation of the recovery plant represents a substantial expenditure and while the reduction in the waste discharged to the James River is a major step, the company recognizes that there will continue to be some waste material discharged and some discoloration of the mill's effluent.

New Bleach Plant

A modern new bleach plant, to be housed in a brick, tile and steel structure measuring approximately 70 by 88 ft. and extending to a height of about 90 ft. will be added to pulp production facilities of Mead's Kingsport Div. during 1956.

The new building will replace existing bleaching equipment, which is no longer adequate for present and future needs of the Kingsport plant. First and second stage bleaching facilities were constructed in 1941 and third stage bleaching equipment, including six bellmers, was installed at the time the original pulp manufacturing plant was built in 1917.

The new bleach plant will include facilities for four-stage bleaching: first, raw pulp will be chlorinated and washed, then given an alkaline extraction and washed again, and then given a calcium hypochlorite bleach, after which the pulp flow will be split. Part of the flow will be passed over a washer and used in the paper mill. This portion of the pulp will be stored in a new high density stock storage chest until needed. The other part of the pulp flow will be passed over another washer and then given a fourth stage calcium hypochlorite bleach. This portion of the pulp flow will then be washed and passed also into a high density storage chest for use by the dry pulp machine or the paper machines as needed.

Plans for the new bleach plant call for a structure having enclosed top and bottom floors, with intermediate floors remaining open. The new building will be located adjacent to the brown stock washer building, on the site of the old pan and evaporator room and a portion of the old digester building. This area is now being cleared preparatory to beginning of the new construction program.

In addition to the bleach plant, plans call for a new screen room to be located alongside the brown stock washer building, replacing the present screen room on the top floor of the bellmer building.

A new water softening plant will be constructed this fall to furnish water of proper quality for the new bleaching facilities. An additional sewer line from the mill to the river, required to serve the bleach plant, will be installed also this fall. Actual construction of the bleach plant and the screen room is slated for early next year.

Gair

The Gair Co. has just completed a major phase of its long-range expansion program in the South.

It has acquired the Southern Advance Bag and Paper Co., which operates a paper mill and bag plant at Hodge, La., and which has extensive timberland holdings, and the Great Southern Box Co., which manufactures shipping containers at three plants in Louisiana and Mississippi.

Combined 1954 sales of Gair, Southern Advance and Great Southern totaled $147 million, of which Gair's share was $117 million.

This gives the company a total of 40 mills and plants in the United States and Canada. The two new additions have 2,125 employees who are now welcomed into the Gair family.

These acquisitions, accomplished within two weeks of each other in May, are two of the biggest steps Gair has taken in its program of expansion in the industrial South. In earlier moves, the company formed the subsidiary Southern Paperboard Corp., which operates a huge kraft mill on the Savannah River in Georgia. A subsidiary of Southern Paperboard, Gair Woodlands Corp. owns and manages 330,000 acres of timberlands in three southern states. Gair acquired shipping container plants in Richmond and Martinsville, Va. and recently opened a new container plant in Atlanta, Ga.

Gair plans to continue unchanged the existing organizations of Southern Advance and Great Southern. The properties and business of Southern Advance and its subsidiaries will be operated as the Southern Advance Bag and Paper Div. of Gair, under the direction of Robert L. Fitts, who has been president of Southern Advance, and the associates who have worked with him in building up and operating that company. Mr. Fitts has been named general manager of this new division.

Properties and business of Great Southern will be operated as the Great Southern Box Div. of Gair, under the direction of Shelley Schuster, who has been president of Great Southern, and his staff. Mr. Schuster has been appointed general manager of the southern district for Gair's container operations.

Mr. Fitts, Mr. Schuster, and two other former officers of Southern Advance, John C. Michaud and Wilbur W. Bullen, have been elected to Gair's board of directors. Mr. Fitts was also elected a vice president of the Gair company.

Mortimer Williams has been appointed products development manager for Gair's Boxboard Div., New York, N. Y.

St. Regis

St. Regis Paper Co. and General Container Corp. of Cleveland, Ohio, jointly announced recently that the holders of substantially more than the majority of General's outstanding capital stock have signed an agreement granting St. Regis options to acquire their shares in exchange for shares of St. Regis common stock.

General Container, whose principal offices are in Cleveland, had sales in 1954 in excess of $23,000,000. At the end of 1954, General had 134,656 shares of common stock outstanding with no preferred stock or bonds.

General is engaged in the manufacture of corrugated fiber shipping containers and allied products, folding cartons and set-up boxes, and corrugating medium and container chipboard. Its customers include manufacturers of automotive parts, household appliances, food products, metal products, textiles, paper converters, and the jobbing and retail trades.

The products manufactured by General are produced at plants at the following locations:

Corrugated fiber containers and allied products:
Albany Corrugated Container Corp., Cohoes, N. Y.
Canton Corrugated Box Co., Canton, Ohio
Cleveland Corrugated Box Co., Cleveland, Ohio
Dubuque Container Co., Dubuque, Iowa
Hunt-Crawford Co., Coshocton, Ohio
Niagara Corrugated Container Co., Inc., Buffalo, N. Y.
Folding cartons and setup boxes are manufactured by:
Great Lakes Box Co., Cleveland, Ohio
Crowell Carton Co., Marshall, Mich. (folding cartons only)
Dubuque Container Co., Dubuque, Iowa
Corrugated medium and container chipboard is produced by:
Muskingum Fiber Products Co., Coshocton, Ohio

Approximately 1400 persons are employed in General's nine plants. If the negotiations for General's acquisition are consummated, it is stated that the entire General organization will remain unchanged and management continued as in the past with Dan L. Pickering, chairman of the board, and Robert W. Alger, president.

W. R. Grace

A Pandia continuous cooker was chosen for the first Peadco process pulping unit of the famous W. R. Grace & Co. bagasse pulp and paper mills at Paramonga, Peru. This plant has so successfully produced high quality pulp at low cost that the Grace Co. recently announced that an additional 115 ton Peadco plant, using continuous digestion, is scheduled for construction in 1956.

The continuous digester used in the present Peadco plant at Paramonga consists of a standard Pandia screw feeder, a single 24-in. Pandia digestion tube and the Pandia discharger. Board, bag, wrapping, and bleachable bagasse pulps of extremely high quality are cooked in the Pandia continuous digester in from 2 to 10 min.—a truly remarkable performance in comparison with the hours-long cycle required in conventional batch-type rotary digester.

The Pandia continuous digester is a product of the pulp mill equipment division of The Black-Clawson Co.; Pandia Inc. Div., 250 Park Av., New York, N. Y.

West Virginia

West Virginia Pulp & Paper Co., long a leading producer of paper and paperboard made exclusively from chemical pulps, has decided to expand its activities in the higher quality printing grades where its chemical pulps can be used to greatest advantage. The company stated that the shift in emphasis is in the field of printing papers only, and that it is a part of West Virginia's five-year, $100,000,000 expansion and improvement program currently under way. The company also pointed out that those customers of publication grades affected will have ample time to choose new sources of supply.

Neenah

Illustrated on this page is a schematic arrangement of a chlorine batch dispensing system similar to that recently installed at the Neenah Paper Co., Neenah, Wis.

It is to be noted that the chlorine is dispensed on a weight basis without the use of conventional scales, which, when used, have always involved considerable maintenance and questionable accuracy due to the corrosion always present where chlorine is used.

The use of the force cell as a weight determining element and dynalog recorder-controller as the interpreting and scheduling means presents a very convenient method of presetting the exact weight to be delivered for a particular batch. It is only necessary to set the index to the proper weight required and throw the manual switch over to "automatic operation" to put the system to work. It is also to be noted that the system is always wet—that is, all lines are filled with liquid chlorine. This greatly reduces corrosion in the line and cuts down the time lag common to long lines.

The system is protected by an expansion chamber as well as a relief valve which discharges to atmosphere. Upon completion of the batch the controlling instrument closes the control valve, stopping the flow of chlorine. At this instant a signal light is lit at the operator's location and an audible signal, such as a vibrating horn or a bell, is sounded to tell the operator that the batch delivery is complete. When the batch has been run out the operator closes the valve at the point of delivery and vents the line beneath that valve by opening the valve which functions as a vacuum breaker.

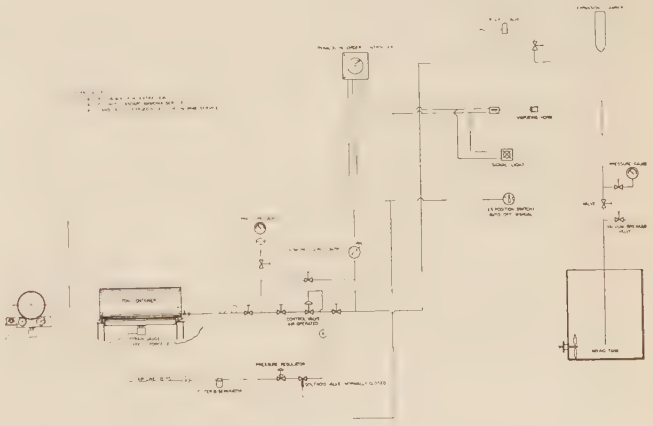
The chart on the control instrument provides a check as to the exact weight of chlorine used, as well as the time increments involved.

A "low pressure" safety device by-passes the instrument, closing the control valve automatically. This takes place when the line pressure drops to 30 p.s.i. and prevents:

1. Excessive chlorine discharge in the event of a broken pipe line, and
2. Siphoning back to the drum due to error in setting the tare, with the instrument calling for more chlorine from an already empty drum.

Features of this system are as follows:

1. Chlorine is delivered to the point of use on a weight basis.
2. A low-cost force-cell replaces the usual scale. No corrosion or maintenance problems arise with force-cells.
3. The system can be operated "automatically" or "manually." Manual finishing of a batch is easily done if required.
4. Controller-recorder permits "zeroing out" of the tare weight of the drums by turning a knob on the instrument cabinet.
5. Weight of chlorine left in the drum is shown on the chart at all times.
6. Weights drawn off on "automatic" or "manual" basis are shown on the chart with respect to the time of day.
7. Adjusting a knob on the instrument permits setting of the weight to be delivered.
8. Exact control is readily established after a brief experience.



Layout of chlorine batch system

Similar arrangements such as this can be used to good advantage in batching with size, alum, liquid SO_2, etc.

Harrisville

The Harrisville Paper Corp., Harrisville, N. Y., formerly owned by St. Regis Paper Co., is again in operation, producing newsprint on its two 114-in. machines.

KVP

KVP Co.'s Canadian subsidiary, Appleford Paper Products, has opened a new converting plant in Montreal, Que.

Ohio Box

The Ohio Boxboard Co., Rittman, Ohio, has acquired a majority of the outstanding stock of the Fairbanks Fiber Box Co., Middletown, Ohio. To be operated with no changes in personnel or policy, Fairbanks is Ohio Boxboard's sixth container converting plant, with other operations at Rittman, Youngstown, Cuyahoga Falls, Pittsburgh, and Lockport. The company's folding carton operations are at Rittman, Cleveland, Norwalk, and South Bend.

St. Croix

St. Croix Paper Co., Woodland, Me., is planning a $13 million expansion program which will involve purchase of a new high-speed newsprint machine, pulp grinders, boiler, and turbine. Increased capacity is expected to amount to 35,000 tons per year.

Simpson

Paul F. Peterson has been named comptroller of Simpson Paper Co., Everett, Wash.

Simpson's new coating mill is now in production. In addition to coating color preparation equipment, the mill includes a 60-in. air blade coater, a high speed drier, and a flying splicer.

Bergstrom

Bergstrom Paper Co., Neenah, Wis., is planning to move its finishing operations to a new location two miles outside Neenah.

American Box Board

American Box Board Co., Filer City, Mich., is showing landowners and hunting clubs how to manage their aspen to produce pulpwood crops as well as deer browse in the form of tops and new growth. Starvation has long been a problem of the Michigan deer herd. One hunting club which previously spent several thousands of dollars each year on alfalfa hay to feed their deer, this year received $7000 for cutting rights and has, in addition, more natural deer food than before.

Riegel Carolina

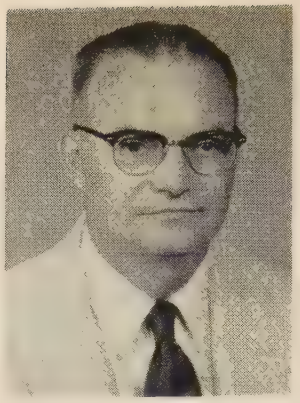
Riegel Carolina Corp., Acme, N. C., has started an expansion program that will include two new digesters, a filter plant expansion, a recovery boiler, a turbo-generator, evaporator, green liquor clarifier and storage tank, mud washer, lime slaker, brown stock washer, Sprout-Waldron refiner, notary and flat screens, 36 additional driers on the Kamyr machine, a line of bale conveyors with press, tyer and stacker, two ClO_2 reactors, and a ClO_2 absorption tower.

Western Michigan

R. A. Diehm, executive vice-president and general manager of the Ward Paper Co., Merrill, Wis., will become an associate professor of paper technology at Western Michigan College, beginning in the fall semester.

This is the second major addition to the paper faculty this year, with Miss Carola Trittin, technical director at Ward Paper, coming to Western in June as assistant professor.

Registrants at Western Michigan's second three-week course in Principles and Practice of Coated Paper Manufacture are listed below by states.



R. A. Diehm, Western Michigan College

Carola Trittin, Western Michigan College

Indiana—Robert May, Beveridge Paper Co., Indianapolis
Iowa—Paul Shirley, Penick and Ford, Inc., Cedar Rapids; J. E. Boyle and J. Bauer, The Hubinger Co., Keokuk
Michigan—Lawrence Brown, St. Regis Paper Co., and Anthony Powloski, Kalamazoo Paper Co., Kalamazoo; Paul Waber, MacSimBar Paper Co., Otsego
Minnesota—Karl Ryan, Blandin Paper Co., Grand Rapids
New Jersey—Gerald Hale, Minerals & Chemicals Corp. of America, Metuchen
New York—George Booth, Dilts Machine Works, Fulton
Ohio—Logan W. Mather, Gardner Board & Carton Co., Middletown
Ontario—Malcolm C. Wyatt, Howard Smith Paper Co., Cornwall
Oregon—Paul Henry, Crown Zellerbach Corp., West Linn
Pennsylvania—William E. Welliver, Jr., New York & Pennsylvania Co., Lock Haven; Henry Smaine, P. H. Glatfelter Co., Spring Grove
Tennessee—Wendall E. Bryan, The Mead Corp., Kingsport
Texas—Hubert D. Foster, Champion Paper & Fibre Co. Pasadena
Virginia—Michael H. Ober, Camp Mfg. Co., Franklin; James L. Baker, Albemarle Paper Mfg. Co., Richmond
Wisconsin—S. C. Slifkin, Products Research & Development Co., Milwaukee

University of Maine

J. L. Ober, vice-president of the Scott Paper Co., Chester, Pa., was re-elected president of the University of Maine Pulp

At the Western Michigan second coating course first row, left to right: W E. Welliver, Jr., W. E. Bryan, H. D. Foster, M. C. Wyatt, R. N Zabe, George Booth, Paul Waber and A. H. Nadelman. Second row: Paul Henry, M. H. Ober, Lawrence Brown, Anthony Powloski, J. E. Boyle L. W. Mather. Third row: Miss Carola Trittin, Robert May, Henry Smaine, Gerald Hale, J. Bauer. Fourth row S. C. Slifkin, Dale Leedy (lab. technician), J. L. Baker, Karl Ryan, Paul Shirley

and Paper Foundation at the recent annual meeting of the Foundation at the University of Maine.

Other officers elected included W. E. Parsons, president of the Keyes Fibre Co., Waterville, vice-president; F. A. Soderberg, vice-president of F. C. Huyck and Sons, Rensselaer, N. Y., vice-president; H. W. Fales, vice-president and general manager of the St. Croix Paper Co., Woodland, secretary; and R. A. Wilkins, vice-president of Bird and Son, Inc., East Walpole, Mass., treasurer.

In addition to the officers the following were elected to the board of directors: M. C. McDonald, president of the Great Northern Paper Co., Bangor; P. S. Bolton, research and technical director of the Robert Gair Co., Inc., Uncasville, Conn.; L. C. Jenness, head of the department of chemical engineering, University of Maine; T. G. Mangan, manager of the International Paper Co., Chisholm; A. S. Campbell, dean of the College of Technology, University of Maine; H. E. Holden, president of the Eastern Corp., Bangor; E. A. Whitney, president of the board of trustees of the University of Maine; E. P. Ingalls, vice-president of S. D. Warren Co., Cumberland Mills; A. A. Hauck, president of the University of Maine; E. H. Clapp, president of the Penobscot Chemical Fibre Co., Great Works; W. H. Chisholm, vice-president of the Oxford Paper Co., Rumford; E. A. Ellis, president and treasurer of the Downingtown Mfg. Co., Downingtown, Pa.; H. C. Moore, president of the Beloit Iron Works, Beloit, Wis.; P. H. Glatfelter, III, president of the P. H. Glatfelter Co., Spring Grove, Pa.; J. D. Cowan, vice-president of the West Virginia Pulp & Paper Co., New York, N. Y.; S. B. Copeland, president of The Northwest Paper Co., Cloquet, Minn.; and Everett K. Mansfield, consultant of the Robert Gair Co., New York, N. Y. J. A. Gannett, Orono, was re-elected resident secretary.

The scholarship fund for the year 1955–56 was established by the directors at $30,000 to provide tuition scholarships for juniors and seniors and grants of $1200 for students in the fifth year of the five-year program.

The report of the membership committee listed 60 companies and 190 alumni and friends in the paper and allied industries that are contributing annually to the Foundation.

The purpose of the University of Maine Pulp and Paper Foundation is to advance fundamental and applied research in pulp and paper technology at the university, as well as to increase the teaching facilities in this field and to provide financial assistance for undergraduates.

Completing a 2-week summer course given by the paper engineering department at Lowell Technological Institute for men in the industry were those shown, left to right. Front: John Langstaff, Monsanto Canada Ltd., Montreal; Lee Thomas, Albany Felt Co., Albany, N. Y.; Kimon Ayanoghi, Albany Felt Co., Albany; Robert Olds, Shellmar-Betnar Div., Continental Can Co., Mount Vernon, Ohio; Prof. John Lewis, L.T.I. paper department head; Prof. N. H. Keeney, Jr., of the department. Rear: Robert Gregory, Albany Felt Co., Albany, N. Y.; Raymond Andrews, Byron Weston Co., Dalton, Mass.; William Laliberty, Merrimac Paper Co., Lawrence, Mass.; William Hicks, Monsanto Chemical Co., St. Louis, Mo.; Fred Leary, Carter, Rice & Co., Boston, Mass.; John Smith, Merrimac Paper Co., Lawrence. Absent when the photograph was taken were Elmer Rossen, Monsanto Chemical Co., Springfield, Mass.; and William Crosby, St. Regis Sales Corp., New York, N. Y.

Downington

We have learned that arrangements have been completed according to which K. F. Landegger will assume the presidency of the Downingtown Manufacturing Co. on Sept. 20, 1955. The operations of the Downingtown shop will continue unchanged. It is the intention that the vacuum equipment line, especially the suction rolls, will be transferred to the Black-Clawson Co. which has previously not manufactured this line.

Torrington

Promotion of eight executives of the sales organization and formation of new divisions have been made by The Torrington Co., Torrington, Conn. The promotions are: Donald E. Lewis to be sales manager, Bearings Div., at Torrington; Raymond G. O'Connell to be assistant sales manager, Bearings Div.; Richard A. Ramsay to be manager of Torrington's Detroit, Mich., office; Clarence H. Rowe to be sales manager, Needle Div.; C. Raymond Johnson to be assistant sales manager, Needle Div.; Wesley B. Meeteer to be manager, Torrington Needle Office, Chicago, Ill.

It has been decided to split the Specialty Sales Department in order to give better service to the individual product lines. The three new divisions will be Swaging Machines, Surgical Needles, and Specialties (precision metal parts). Robert A. Clarke is appointed sales manager of Swaging Machines and Surgical Needles Div. Richard S. Keppelman is appointed sales manager of the Specialties Div.

Sprout, Waldron

Sprout, Waldron & Co., Inc., Muncy, Pa., and V. D. Anderson Co., Cleveland, Ohio, have developed the S-W–Anderson fiberpress for the pulp and paper industry.

F. B. K. Green, Sprout, Waldron & Co., Inc.

This press, which is made in three sizes, has two important functions: dissolved solids removal at high concentration, and fiberizing action. The press is an invaluable part of semichemical pulping systems where liquor disposal is a problem, because it removes the black liquor and dissolved solids from the fiber at the highest possible concentration thus producing a favorable condition for black liquor disposal or recovery. The high dissolved solids content of the black liquor, slightly higher than the solids content of the free black liquor from the digesters, encourages chemical recovery since evaporation costs are reduced to an acceptable figure. If the black liquor is ponded, the press greatly increases the capacity of the pond. When the black liquor is used as a road binder, its efficiency is increased and the volume of liquor handled is very much reduced.

The outstanding feature of the fiberpress is its two-stage press design and the use of a vertical press for the initial pressing. The vertical press section, driven by a 50-hp. motor, removes about 60% of the liquor and dissolved solids. It feeds into the horizontal press section. The horizontal section completes the pressing and discharges the fiber in the form

of small particles of coarse shives and fiber. The horizontal section is driven by a separate 50-hp. motor.

The two press sections work together to produce a uniform pressed fiber. Interlocking devices will shut down the preceding press section and the feeder if an overload occurs in a section. These sections will start up again automatically as the overload clears.

The discharge consistency and, hence, the power input, is regulated by a simple, patented adjustable choke mechanism consisting of choke bars which may be positioned to impede the discharge of the material to a varying degree, depending upon the distance of the end of the choke bars from the shaft. This is the simplest and most effective press regulating device available.

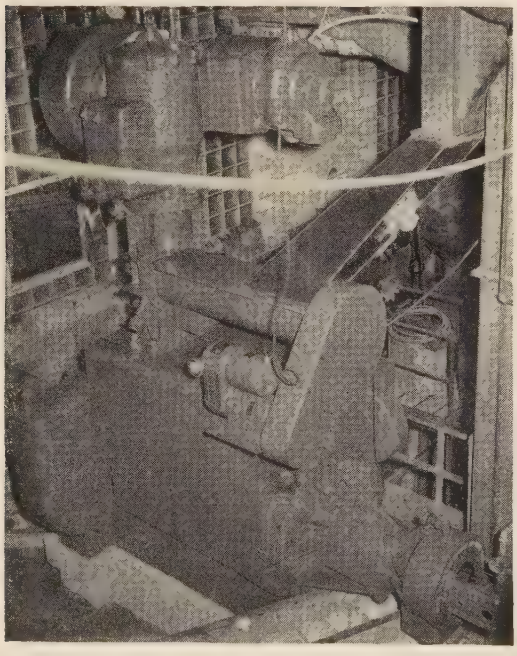
The discharge consistency on moisture-free total solids basis when pressing hardwood neutral sulphite semichemical chips will normally be 60 to 65%. As an example, aspen neutral sulphite semichemical chips entering at 25% moisture-free consistency, are discharged at 60% moisture-free total solids minimum at a production rate of 65 to 70 tons moisture-free total solids per 24 hours.

The S-W–Anderson fiberpress, according to the manufacturers, has the following advantages:

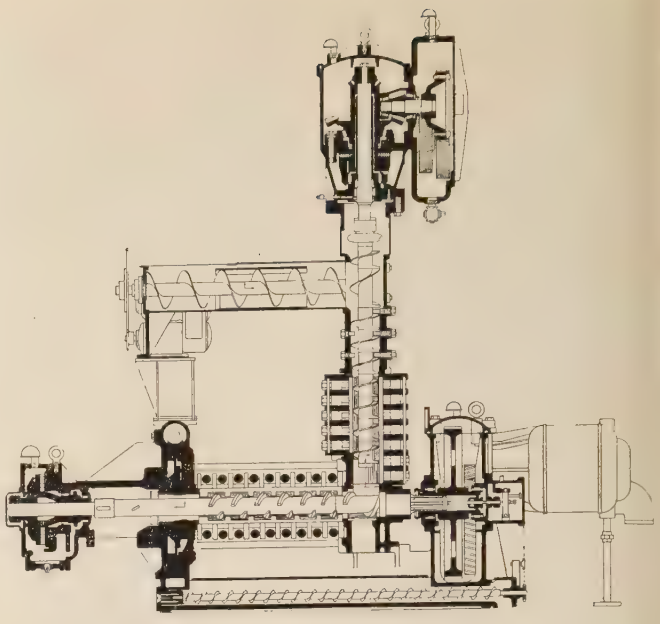
1. Two pressing stages for most complete liquor removal.
2. More complete fiberizing of the semichemical chips.
3. Simpler mechanical design and lower replacement parts cost.
4. Convenient, nonplugging adjustment of the discharge consistency.
5. At least 10% greater capacity with the same horsepower input.

All parts of the press in contact with the process liquors are suitable corrosion-resistant material. Barrel bars are of stainless steel, the shaft is Stellite-faced. The barrel bar spacers are stainless steel. Other parts are corrosion-resistant material wherever required.

The fiberpress is also used as a part of the S-W–Anderson chip washing system. This is a two-stage extraction pressing system comprising an extractor followed by the fiberpress. It has a washing efficiency of 93% minimum, using not more than 1.5 lb. of water per pound of moisture-free fiber.



Sprout-Waldron–Anderson fiberpress installed at Watervliet Paper Co., Watervliet, Mich. Hardwood neutral sulphite cooked chips pass through a magnet-equipped chute into the adjustable speed conveyor which feeds the press. The installation is neat, compact, and requires little floor space



Cross section of the V. D. Anderson–Sprout-Waldron fiberpress. Chips from the screw feeder enter the vertical press section, driven by a 50-hp. motor where about 60% of liquor and soluble solids are removed. Horizontal section, also driven by a 50-hp. motor, completes pressing and discharges the chips in the form of shives and fiber at consistencies above 60% moisture-free

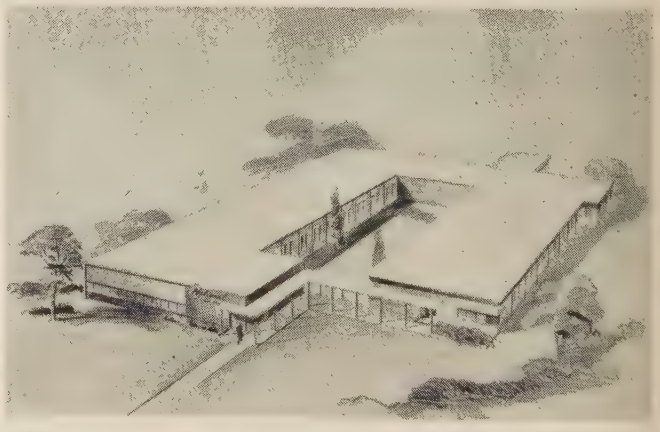
In addition to the fiberpress, Sprout, Waldron is also offering the S-W–Anderson moisture expeller, a screw press especially designed to produce a medium consistency of 20 to 40% moisture-free. It is driven by a 15-hp. motor. The following table, based on unbleached kraft entering at 8% moisture-free consistency indicates its capacity:

Discharge consistency, per cent moisture-free	*Production, moisture-free tons per 24 hrs.*
37	40
22	60

Frank B. K. Green, has joined the staff of the Pulp and Paper Mill Div. of Sprout, Waldron, as chief development engineer.

National Starch

National Starch Products, New York, N. Y., has started construction of an addition to the Alexander Research Laboratories at Plainfield, N. J.



Artist's conception of the expanded National Starch Products' research and development laboratories, Plainfield, N. J.

In a recent tour of the main plant of Albany Felt Co., Albany, N. Y., Governor Averell Harriman of New York called the plant one of the finest and most progressive industrial plants he had ever seen. The Governor is shown with Lewis R. Parker (left), president, and John C. Standish (right), executive vice-president, as he inspects a partially woven felt on one of the firm's giant looms

ALBANY FELT

Albany Felt Co., Albany, N. Y., has published a new handbook entitled "Suggestions for Improved Felt Performance."

ARMSTRONG

Armstrong Machine Works, Armstrong, Mich., has published a bulletin (No. 500) "Humidification for Profit," giving data on losses caused by dry air during the heating season.

RHEEM

Gordon W. Mallatratt, general manager of the Rheem Products Div., has been named a vice-president of the Rheem Mfg. Co., Chicago, Ill. William S. Rheem II, general manager of the company, has been elected to the board of directors and named a vice-president.

FOXBORO

The Foxboro Co., Foxboro, Mass., has contracted with Yokogawa Electric Works Ltd., Tokyo, Japan, for the manufacture and sales of Foxboro instruments in Japan.

Shown above are James E. Smith, assistant sales manager of Albany Felt Co.; G. Lamont Bidwell, manager of the Riegel Paper Corp., Milford, N. J., mill; Glenn Drake, guest speaker on selling; and Wayne G. Davis, Albany Felt vice-president in charge of felt sales. Mr. Bidwell addressed a recent Albany Felt semi-annual sales meeting on the subject, "A Paper Mill Manager Looks at Felt Salesmen"

HUBINGER

The Hubinger Co., Keokuk, Iowa, has made the following appointments: Delbert L. Edwards, manager of bulk sales in Iowa, Nebraska, Missouri, Kansas, Colorado, Oklahoma, Arkansas, Eastern Tennessee, Texas and Southern and Central Illinois; Duane L. Tiger, Chicago Branch manager; Howard L. Peper, assistant Chicago Branch manager.

FOSTER WHEELER

Foster Wheeler Corp., 165 Broadway, New York 6, N. Y., has issued a catalog on the new series of Foster Wheeler packaged steam generation in sizes 10,000 to 46,000 lb. per hr.

OLIN-MATHIESON

William C. Foster, former Deputy Secretary of Defense and president of the Manufacturing Chemists Association, is now executive vice-president of Olin-Mathieson Chemical Corp., New York, N. Y.

HONEYWELL

Minneapolis-Honeywell Regulator Co., Wayne and Windrim Aves., Philadelphia, Pa., has issued a bulletin (no. 1130), "Program Control of Process Variables," describing methods and advantages of employing automatic, time-conditions control for many industrial processes and tests.

TAYLOR

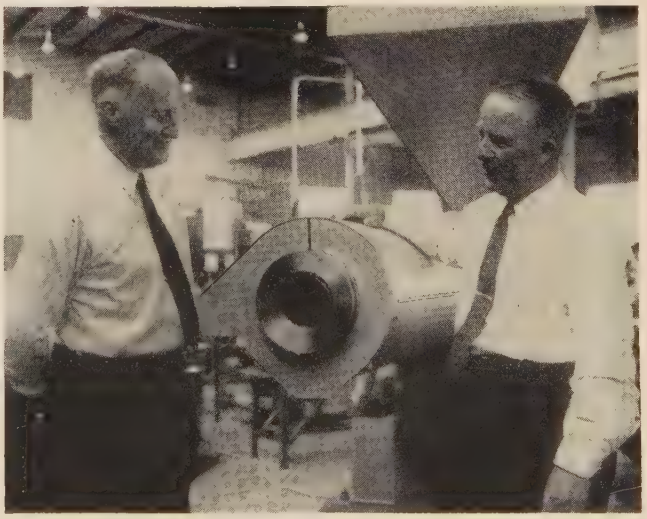
Alvin J. Fink has been appointed regional manager in charge of industrial sales operations for Los Angeles and the intermountain territory for Taylor Instrument Co., Rochester, N. Y.

EMERSON

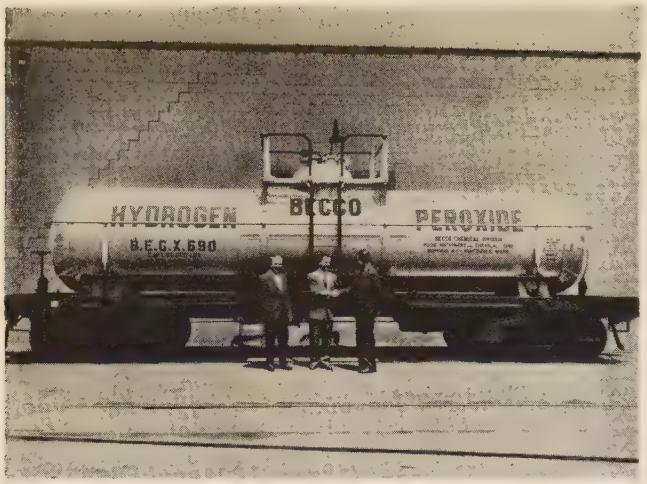
The United States Machinery Co., 90 Broad St., New York, N. Y., has been appointed exclusive Export Engineering and Sales Dept. for the Emerson Mfg. Co., a division of John W. Bolton & Sons, Inc., Lawrence, Mass.

EGAN

Frank W. Egan Co., held "open house" recently to celebrate the opening of its new plant at 36 S. Adamsville Rd., Somerville, N. J.



Frank W. Egan, president and founder of Frank W. Egan & Co., discussing the new plant and production facilities of his company at the open house when the new plant was dedicated on June 30. R. G. Macdonald, secretary of the Technical Association of the Pulp and Paper Industry, on the left, is the interested listener



First tank car of non-electrolytically manufactured Becco hydrogen peroxide shipped from the new plant. Left to right, John F. Shea, vice-president in charge of sales; Joseph A. Bergantz, project engineer; Frederick A. Gilbert, vice-president

BECCO

The Becco Chemical Div., Food Machinery and Chemical Corp., Buffalo, N. Y., is expanding its hydrogen peroxide producing facilities at Buffalo and at Vancouver, Wash.

PERMUTIT

The Permutit Co., New York, N. Y., has developed a compact demineralizer, Model MBD-15, for the demineralization of up to 360 gallons of water per hour.

STEIN, HALL

Stein, Hall & Co., New York, N. Y., has reorganized its adhesives research facilities at Long Island City, N. Y. Tom G. Heiser has been appointed director of adhesive research, Bill Neuss is now chief chemist, Adhesive Technical Service, and Leonard Zyzyck is chief chemist, Adhesive Research and Development. Frank Littenberg was named chief chemist, Quality Control.

MUTUAL BOILER

Mutual Boiler and Machinery Insurance Co. has moved its home office to 225 Wyman St., Waltham, 54, Mass.

B & O

The Baltimore and Ohio Railroad has extended its Tofcee service for the handling of highway trailers on flat cars to the Wheeling, W. Va., district.

John Edwards, Jr. has retired as general manager of B & O's Eastern Region.

BORDEN

The Borden Co's. Chemical Div., 350 Madison Ave., New York, N. Y., has issued a guide to the use of Elmer's Contact Cement, designed for furniture fabricators.

BOLTON

The following appointments have been made by John W. Bolton & Sons, Lawrence, Mass.; Wallace L. Bolton, manager of the Emerson Division; Arthur F. Sherman, plant manager; Charles E. Fisk, chief industrial engineer.

BLACK-CLAWSON

Frank T. Peterson has been elected a director of the Black-Clawson Co., New York, N. Y.

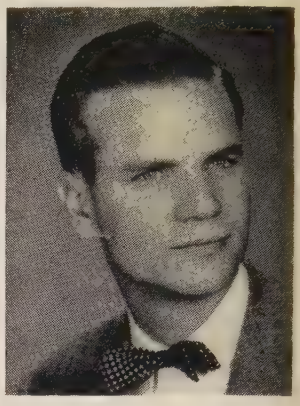
B-C is planning an extensive tooling and foundry expansion program at its Bagley-Sewall Div., Watertown, N. Y. The company will also expand its research and development program as well as its manufacturing activities at Newport, Monmouthshire, England, and its sales and engineering staffs in London. Also contemplated is an expansion into new lines of equipment for papermaking and converting.

BAUER

LeRoy J. Bauer has been appointed New England sales representative for Bauer Bros. Co., Springfield, Ohio.

BENSING BROS. & DEENEY

John B. Plunkett has been appointed director of quality control and purchases for Bensing Bros. & Deeney, Philadelphia, Pa., manufacturers of BBD Printing Inks.



L. J. Bauer, Bauer Bros. Co.

GENERAL ANILINE & FILM

The following promotions have been made in the Dyestuff and Chemical Div. (includes General Dyestuff Co. and Antara Chemicals) of General Aniline & Film Corp., New York, N. Y.: Edward R. Heintz, manager, Pigment Div., General Dyestuff Co.; Thomas R. Moore, Jr., Philadelphia Branch Manager; Kenneth J. Campbell, assistant to the vice-president and general manager; Henry K. Schweighofer, market manager, Textile Dyestuffs; Ernest G. Tesch, manager, Dyestuff Sales Service.

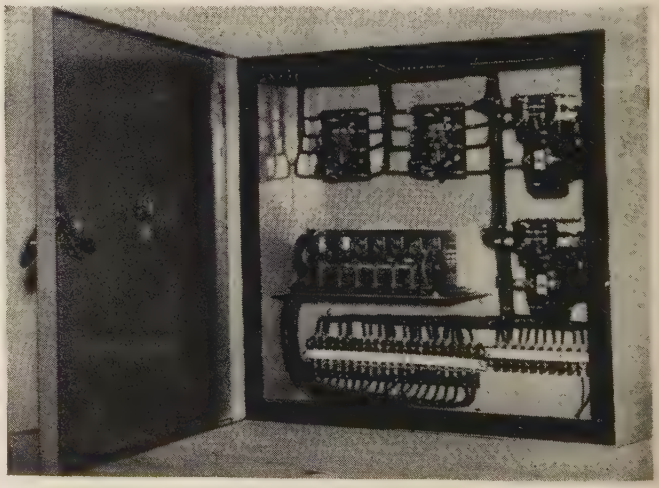
FISCHER & PORTER

Fischer & Porter Co., Hatboro 35, Pa., has issued a new catalog illustrating its complete line of filled thermal systems for indicating, recording, controlling, transmitting, compensating, and programming temperatures from −400 to 1000°F.

GRAVER

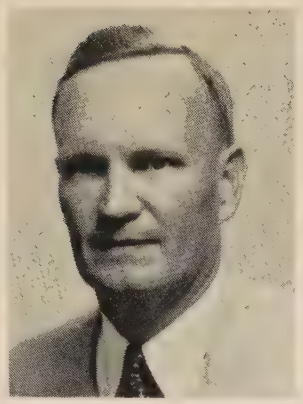
Graver Water Conditioning Co., New York, N. Y., is offering two different types of desludging control for its solids-contact unit, the Reactivator. One control operates on a time cycle, the other on a flow meter which sets the backflush and then the blowdown valve operation after a predetermined volume of water has been handled.

Graver has developed a new automatic control system for dual tank zeolite softeners, featuring an electrical control panel which initiates periodical regeneration of the softeners.

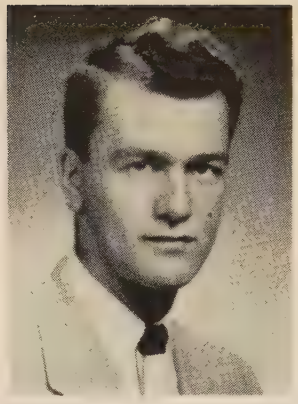


Automatic control system developed by Graver for dual tank zeolite softeners

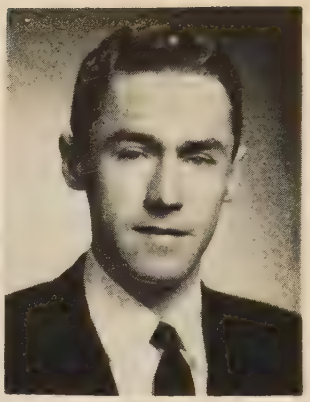
J. G. MacKechnie, Eastwood-Nealley Corp.



N. W. Webb, Eastwood-Nealley Corp.



J. H. Coppens, H. Waterbury & Sons Co.



F. W. Kopplow, Jr., H. Waterbury & Sons Co.

EASTWOOD-NEALLEY

John G. MacKechnie has been elected president, and Nelson W. Webb executive vice-president of Eastwood-Nealley Corp., Belleville, N. J.

GOODYEAR

The Goodyear Tire & Rubber Co., Akron 16, Ohio, has issued a bulletin describing the properties of its small particle size nitrile latices, Chemigum Latex 236 and 246.

BABCOCK & WILCOX

Babcock & Wilcox, New York, N. Y., has issued a data folder (TB-355) on B & W seamless stainless tubing and pipe.

G. E.

General Electric Co., Schenectady, N. Y., reported recently that 80% of all 1–5 hp. G.E. induction motors sold today are built to the new NEMA dimensions.

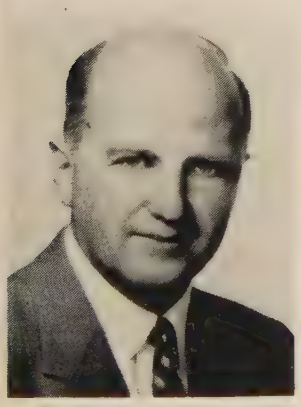
G.E. will supply the largest steam turbine-generator in the paper industry to International Paper Co. for its newsprint mill at Mobile, Ala. The 40,000-kw. single automatic-extraction condensing unit and turbine to operate at a throttle pressure of 1450 p.s.i. at 1000°F. will be shipped by the middle of 1956.

RICE BARTON

Rice Barton Research Corp., Worcester, Mass., has issued a folder describing the DynoMiser, a high consistency pulper particularly adapted to deinking systems. The unit dewaters the slushed pulp up to 20% and re-uses the water for pulping.

JOHNS-MANVILLE

Clinton B. Burnett has been appointed general manager of the Celite Div. of Johns-Manville Corp., New York, N. Y., replacing Arthur S. Elsenbast, who retired July 21.



C. B. Burnett, Johns-Manville Corp.

A. S. Elsenbast, Johns-Manville Corp.

WATERBURY

John H. Coppens has joined the sales staff of H. Waterbury & Sons Co. as representative for Illinois, Minnesota, and Wisconsin. F. W. Kopplow, Jr., becomes sales representative for Ohio, Indiana, and Michigan.

CRUCIBLE

Crucible Steel Co. of America, P.O. Box 88, Pittsburgh, Pa., has published a booklet entitled "Tool Steels for the Non-Metallurgist," intended to familiarize the nonmetallurgist with the six basic classifications of tool steels.

STEBBINS

The Stebbins Engineering and Mfg. Co., Watertown, N. Y., has published a revised edition of its booklet, "Table of Circles."

AMERICAN KEY PRODUCTS

American Key Products, Inc., New York, N. Y., has erected a potato starch plant at Moses Lake, Wash., under the name of Pacific Starch Co. The plant is owned and operated by Menan Starch Co., Idaho Falls, Idaho.

RELIANCE

Reliance Electric and Engineering Co., 1088 Ivanhoe Rd., Cleveland, Ohio, has issued a bulletin (A-2406) "New Automatic Grease Monkey," describing its Metermatic prelubricated bearing design.

OBITUARY

Gerald Frederick Alcorn

Gerald F. Alcorn, chief construction engineer of the Pulp Div., Weyerhaeuser Timber Co., died suddenly on July 29, 1955, at Longview, Wash.

Mr. Alcorn was born in Yakima, Wash., on May 12, 1908, and graduated as a chemical engineer from the University of Washington in 1931.

Following graduation he joined the Weyerhaeuser organization as an analytical chemist. In 1945 he became plant engineer and in 1946 became manager of the Longview mill. In 1954 he became chief construction engineer for the division.

Mr. Alcorn has been a member of the Technical Association of the Pulp and Paper Industry since 1931.

TAPPI DIVISIONS AND COMMITTEES

Reports of Activities

Pulp Testing Committee

A luncheon meeting of the TAPPI Pulp Testing Committee (Western Section) was held May 20, 1955, at the Empress Hotel in Victoria B. C., during the Western International Meeting of the Pulp and Paper Industry. Present were Frank Caskey, committee chairman, R. G. Macdonald, Secretary-Treasurer, National TAPPI, John M. McEwen, acting chairman, Pacific Section TAPPI, Norval Magnusson, Elmer Christoferson, and Otto Sangder.

The meeting was opened by Frank Caskey with a review of the Reference Pulp Program. A report outlining the Reference Pulp Program together with suggested form to be included with each package of standard pulp for reporting results was distributed from Al Graef who was unable to be present. A discussion was held on methods of disseminating information and Mr. Macdonald stated that a similar proposition with regard to fiber specimens had worked out very well. The following actions concerning the Reference Pulp Program were taken:

1. Mr. Macdonald is to check with the National TAPPI Executive Committee on the financing of the program. The cost of the bare pulp wrapped in Everett would be around $1000 and it was decided to ask for $3000 to cover handling, storage, etc. The program should in time pay for itself.

2. Frank Caskey is to write three paragraphs on the program for sending to Corporate Members.

Other subjects briefly discussed were:

1. Revision of TAPPI Standard T 227 m-50 Freeness of Pulp: Frank Caskey stated this should be completed next Fall.

2. Dirt Evaluation: Elmer Christoferson discussed the problems with the view of finding some practical and reproducible method for dirt evaluation. It was thought the best way of determining the needs of the industry in this respect was to hold discussion-type program with representatives from both paper and pulp mills.

Subcommittee meeting for Mullen Testing Procedures held on the 16th of June: C. Root, alternate for R. C. McKee, Institute of Paper Chemistry, Appleton, Wis.; R. E. Swingle, Acme Steel Co., Chicago, Ill.; E. O. Knapp, Hinde & Dauch Paper Co., Sandusky, Ohio; A. V. Grundy, (chairman) and Col. George F. McAneny, QM Food and Container Institute for The Armed Forces, Chicago, Ill.; C. J. Zusi, Container Laboratories, Inc., Chicago, Ill.; and W. J. Balster, Don L. Quinn Co., Chicago, Ill.

3. Review of TAPPI Standard Methods: The question of how often the TAPPI methods should be reviewed when not revised was discussed. Mr. Macdonald suggested that when a method had not been revised in the meantime, it be reviewed every five years and if no change appeared desirable the method be reissued with a new confirmation date.

4. Pulp Physical Testing. Norval Magnusson reviewed his circulatory letter concerning pulp testing practices.

OTTO H. SANGDER, *Secretary*

Optical Properties Committee

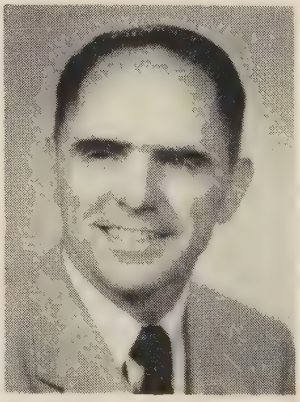
D. Noel Obenshain, West Virginia Pulp & Paper Co., Luke, Md., has been appointed chairman of the Optical Properties Committee, and Richard S. Hunter, Hunter Associates Laboratories, Falls Church, Va., is now secretary of the committee.

Messrs. Obenshain and Hunter are at present engaged in reorganizing the committee and planning future projects. Members of TAPPI who are concerned with optical properties of paper and paper materials are asked by the new chairman to join the committee and present projects for its consideration. The optical properties chosen for study by the committee will be those in which the greatest interest is expressed. Some of the properties which have been proposed for study are:

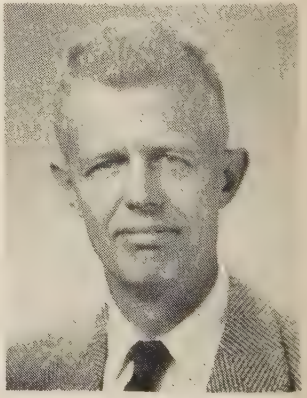
(1) Gloss of cast and lacquer-coated boxboard.
(2) Gloss of label paper.
(3) Gloss of waxed paper.
(4) Gloss of newsprint.
(5) Gloss of book paper.
(6) Brightness of boxboard.
(7) Brightness of tissue.
(8) Brightness of clay.
(9) Printing opacity of book paper.
(10) Printing opacity of newsprint.
(11) Transparency of glassine.
(12) Transparency of waxed paper.
(13) Color of practically all types of paper, especially those with white and near-white colors.
(14) Light-fastness of colored papers.

A meeting of the committee will be held during the Sixth TAPPI Testing Conference at the Sheraton-Kimball Hotel, Springfield, Mass., Sept. 28–30, 1955.

R. S. HUNTER, *Secretary*



D. N. Obenshain, West Virginia Pulp & Paper Co.; Chairman, Optical Properties Committee



R. S. Hunter, Hunter Associates Laboratory; Secretary, Optical Properties Committee

RC-255. Stiffness of Paper or Paperboard (Deflection of Specimen Weight)

This simple stiffness method utilizes materials which are readily available. It uses the deflection of a sample caused by the weight of the sample itself for the calculation of stiffness.

Cut a sample to convenient size. Clamp one end between low-pressure clamping jaws so that the clamping plane is horizontal. Measure the vertical deflection of the free end of the sample. Determine the sample weight in pounds per square inch. Using the following formula for a cantilever beam, calculate the flexural rigidity or stiffness:

$$EI = \frac{wL^4}{8y}$$

EI = flexural rigidity or stiffness in inch-pounds
L = unsupported length, in inches
y = vertical deflection from horizontal plane, in inches
w = sample weight in pounds per square inch

Be sure that the unsupported length of the specimen is not so great that the elementary beam formula will not apply. Unsupported length of the specimen is critical and must be measured with good accuracy since a 1% error in length results in a 4% error in the calculated stiffness.

To allow for any effect of initial curvature of the specimen, two readings should be obtained, the second after removing the specimen from the jaws and inverting it. The mean of the deflections should then be used in the foregoing formula for a uniformly loaded cantilever beam.

The jaws can consist of one metal block laid upon another (with the specimen in between). The specimen can be viewed from the side, using a sheet of graph paper, mounted upon a vertical board, as a back drop for evaluation of length of the extended portion, and deflection of the free end.

Source: J. A. Van den Akker, Institute of Paper Chemistry, Appleton, Wis.

RC-256. Bleachability (for Highly Lignified Pulps)

1. Place in the pan of a Moisture Teller* a portion of wet pulp equivalent to about 10 g. moisture-free. Dry for 10 min. at 200 to 210°F. Remove the pan, crumble the partially dried pulp, and dry for another 5 min.

2. Grind this dry pulp in a Wiley mill to pass a 60-mesh screen.

3. Take approximately 2 grams moisture-free of the ground pulp and place in the Moisture Teller for 5 min.

4. Weigh 1.010 grams of the dry ground pulp on a watch glass as rapidly as possible.

5. In a large beaker or 5-lb. reagent bottle, place 2500 ml. of distilled water and 200 ml. of 4 N H_2SO_4. Adjust the temperature to 25 ± 1° C.

6. Add the weighed pulp sample to this solution and stir throughout the remainder of the test with a mechanical agitator fitted with a glass impeller.

7. Add 200.0 ml. of 0.1 N potassium permanganate from a beaker, washing the beaker clean with 300 ml. of distilled water which is also added to the large beaker.

8. When exactly 10 min. have elapsed from the time the permanganate was added, stop the reaction with 40 ml. of 1 N potassium iodide.

9. Titrate the liberated iodine with 0.1 N sodium thiosulphate, using a starch indicator for the end point.

10. The NSSC number is found by subtracting the milliliters of sodium thiosulphate from 200.

To differentiate this test from the TAPPI permanganate test, the number of milliliters of permanganate consumed is called the NSSC number. The test is simple, fairly rapid, and gives reproducible results. Excellent correlation has been found to exist between the NSSC number and the per cent chlorine required in the first stage of a three-stage bleaching sequence to reduce the TAPPI permanganate number after alkali extraction to 4. A very desirable spread of NSSC numbers was found to result from variations in chlorine demand of neutral sulphite semichemical pulps; there being approximately 4 NSSC numbers for each 1% chlorine required.

Source: Horton Girdler, West Virginia Pulp & Paper Co., Mechanicville, N. Y.

* Available from Harry W. Dietert Co., Detroit, Mich.

ELMENDORF
TEARING TESTER

Measures the internal tearing resistance of paper, textiles and sheet materials in gram-centimeters. Dependent upon gravity for its operation; the readings must be correct. Any two Elmendorfs anywhere will perform alike under like conditions. Tearing resistance is the practical test for predicting wearing quality. It is a measure of service. TAPPI, ASTM and Federal Standard. Made in many capacities.

THWING-ALBERT
INSTRUMENT COMPANY
5383 Pulaski Avenue
Philadelphia 44, U. S. A.

107

Power Requirements for Paper Machines

Revision of TAPPI Data Sheet 145 G

(THIS DATA SHEET IS UNDER THE JURISDICTION OF THE ELECTRICAL ENGINEERING COMMITTEE)

Power Constants for Fourdrinier Paper Machines Other Than Those Producing Tissue

Section	*Hp./in. width/100 f.p.m.* NRL	RDC	*Remarks*
Couch			
Toweling and light wrapping	0.043	0.05	Based on test data from a large number of machines operating with normal vacuum and generally six $7^1/_2$-in. flat suction boxes
Glassine and bond	0.064	0.075	
News, kraft, and book up to 1200 f.p.m.	0.064	0.075	
News, kraft above 1200 f.p.m.	0.086	0.100	
Main Press—Plain or Suction			
Pair of main rolls (all paper and board weights)	(Note 5)	0.030	Based on a maximum nip pressure not exceeding 300 lb. per in. for all paper and board weights and a maximum nip pressure not exceeding 900 lb. per linear in. for pulp sheets
Top roll only	...	0.010	
Pair of main rolls (pulp sheets)	(Note 6)	0.045	
Top roll only	...	0.015	
Dual Press			
Side rolls—each	0.020	0.025	Based on a maximum nip pressure not exceeding 175 lb. per linear in.
Top side roll	...	0.010	
Smoothing Press—Marking Press			
Pair of rolls	0.007	0.012	Based on a maximum nip pressure not exceeding 190 lb. per linear in.
Size Press			
Pair of rolls	0.015	0.025	Based on a maximum nip pressure not exceeding 175 lb. per linear in.
Driers—Paper and Felt (Note 2)			
60-in. diam. rolls—each	0.0018	0.0027	For operating speeds above 160 f.p.m. For lower operating speeds see Note 1. Cleaning doctors require additional power as follows: 0.00075 hp./in. width/100 f.p.m. per blade, based on a pressure of 1.0 lb. per in. width which is approximately correct if there is no loading other than the weight of the blade
48-in. diam. rolls—each	0.0014	0.0021	
42-in. diam. rolls—each	0.0013	0.0019	
36-in. diam. rolls—each	0.0011	0.0017	
Breaker Stacks			
Pair of rolls	0.009	0.012	
Calender Stacks—8 and 9 Rolls (Note 3)			
Up to 70-lb. paper	0.035	0.050	Water finish. A real water finish on paper materially increases the load and should be taken into consideration where any power calculations are involved. Present available data indicate a 50% increase
70 to 90-lb. paper	0.056	0.060	
90 to 130-lb. paper	0.056	0.080	
130 to 225-lb. paper	0.056	0.100	
Above 225-lb. paper	0.056	0.120	
Reels—Direct Driven (Note 4)			
Up to 125-lb.—except kraft	0.008	0.012	Combination constant speed and center wind reels require two driving motors, each selected in accordance with these constants
Above 125-lb.—except kraft	0.008	0.020	
All kraft paper	0.008	0.020	

Notes:

1. Operating speeds below 160 f.p.m.
When sleeve bearings are employed on driers operating below 160 f.p.m. the running load increases rapidly and the following multipliers should be applied to both the NRL and RDC constants in estimating the operating power requirement, interpolating as required.

F.p.m.	*Multiplier*
200	1.00
140	1.26
120	1.51
100	1.80
80	2.16
60	2.54
40	3.04

2. Drier starting
Starting torque for driers equipped with sleeve bearings has been considered by electrical manufacturers as $4^1/_2$ times the normal running torque as determined by the NRL constant. Some new machines built since the war and rebuilt old machines have required as much as eight times NRL torque to start the driers when equipped with plain sleeve bearings.
For antifriction bearings starting torques of three times the NRL torque are ample.

3. Starting torque on calenders equipped with plain sleeve bearings should be based on a torque equivalent to 0.15 hp. per in. width per 100 f.p.m.
4. Slip belt reels may require from two to three or more times as much power as above depending on the build-up of the roll since the drive unit runs at constant speed and considerable power is lost in belt slippage.
5. The NRL constant for the pair of main rolls for all paper and board weights should be based on the following calculation:

$$\text{NRL constant} = 0.011 + 0.004\,(P/100)$$

where P = linear pressure in pounds per linear in.

6. The NRL constant for the pair of main rolls for all pulp sheets should be based on the following calculation:

$$\text{NRL constant} = 0.025 + 0.00278\,(P/100)$$

where P = linear pressure in pounds per linear inch.

REFERENCE

Baker, R. R., "Final Report—Press Section Load Requirements," *Tappi* 35, No. 9: 390–394 (Sept., 1952).

Selection of Chipper Drives

TAPPI Data Sheet 158

(THIS DATA SHEET IS UNDER THE JURISDICTION OF THE ELECTRICAL ENGINEERING COMMITTEE)

THE most important single factor influencing chipper drive selection is the maximum production requirement for a 1-hr. period. This maximum production requirement should be determined realistically. Very few chippers operate under conditions where the wood delivery is a steady flow. Quite frequently a shortage of chips occurs and wood is poured into the chipper at an abnormally high rate in an effort to get ahead of pulp production. The motor size must be selected to take care of these production peaks if excessive temperature rise of the motor is to be prevented.

The two salient wood characteristics affecting load are species and wood diameter. A chipper operating on "soft" woods would not produce equal quantities of "hard" wood chips for the same energy consumption. In cases where the *1 hr. maximum production requirement* is the limiting factor in determining the motor rating and where the average log diameter *exceeds* certain permissible limits, it may be necessary to select a motor of larger rating although the *1 hr. maximum production rate* is not to be exceeded. This is due to the effect of excess motor heating with peak loading.

POWER REQUIREMENTS

Motor ratings for chipping "soft" woods are selected on the basis of 7 hp.-hr. per cord and motor ratings for chipping "hard" wood are selected on the basis of 10 hp.-hr. per cord.

Table I. Tabulation of Horsepower Hours per Cord for Various Wood Species

Species	*Shear stress, p.s.i.*	*Recommended hp. hr./cord*
Fir	690	7
Balsam	690	
Aspen	800	
Spruce	950	
Poplar	980	
Pine—northern	800/1040	
Hemlock	1010/1060	
Larch	1200	
Pine—southern	1180/1350	
Gum	1490	10
Maple	1610	
Oak	1700	
Birch	1725	
Hickory	1870	
Locust	2100	

MOTOR SELECTION

Two systems for selection of either synchronous or induction motor horsepowers are included. System no. 1 utilizes formulas and one nomograph. System no. 2 is essentially a nomographic solution and offers a quick check within the calculation form for induction motors.

A maximum slow-down of 30% (minimum speed of 70%) is recommended for wound rotor motors. This corresponds to a full load slip of 6%. Slip at the motor torque breakdown is equivalent to five times rated load slip. There are many chipper installations that run with 6 to 8% slip at rated load. The nomograph included with system no. 1 is designed so that any slip can be selected that is desired.

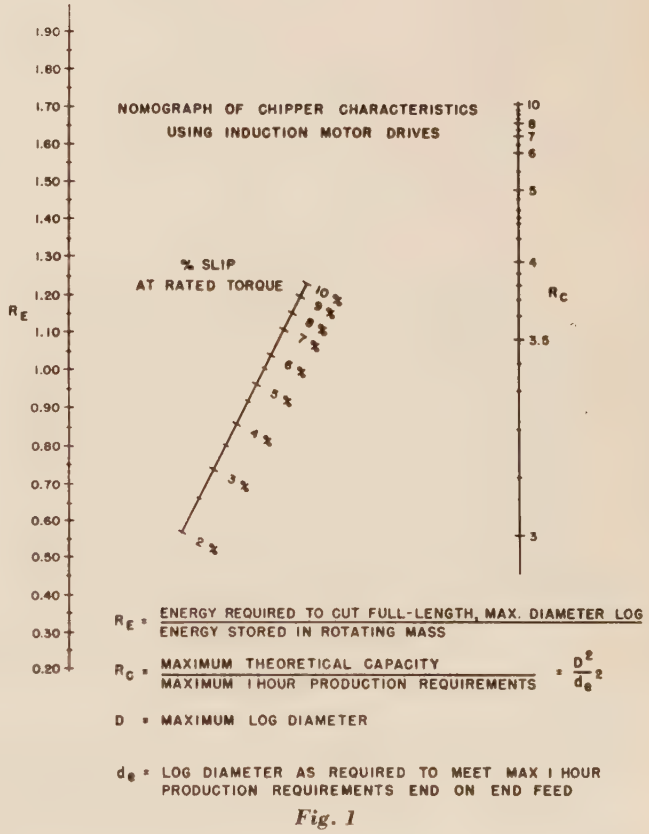

NOMOGRAPH OF CHIPPER CHARACTERISTICS
USING INDUCTION MOTOR DRIVES
% SLIP
AT RATED TORQUE
R_E
R_C
R_E = ENERGY REQUIRED TO CUT FULL-LENGTH, MAX. DIAMETER LOG / ENERGY STORED IN ROTATING MASS
R_C = MAXIMUM THEORETICAL CAPACITY / MAXIMUM 1 HOUR PRODUCTION REQUIREMENTS = D^2/d_e^2
D = MAXIMUM LOG DIAMETER
d_e = LOG DIAMETER AS REQUIRED TO MEET MAX 1 HOUR PRODUCTION REQUIREMENTS END ON END FEED

Fig. 1

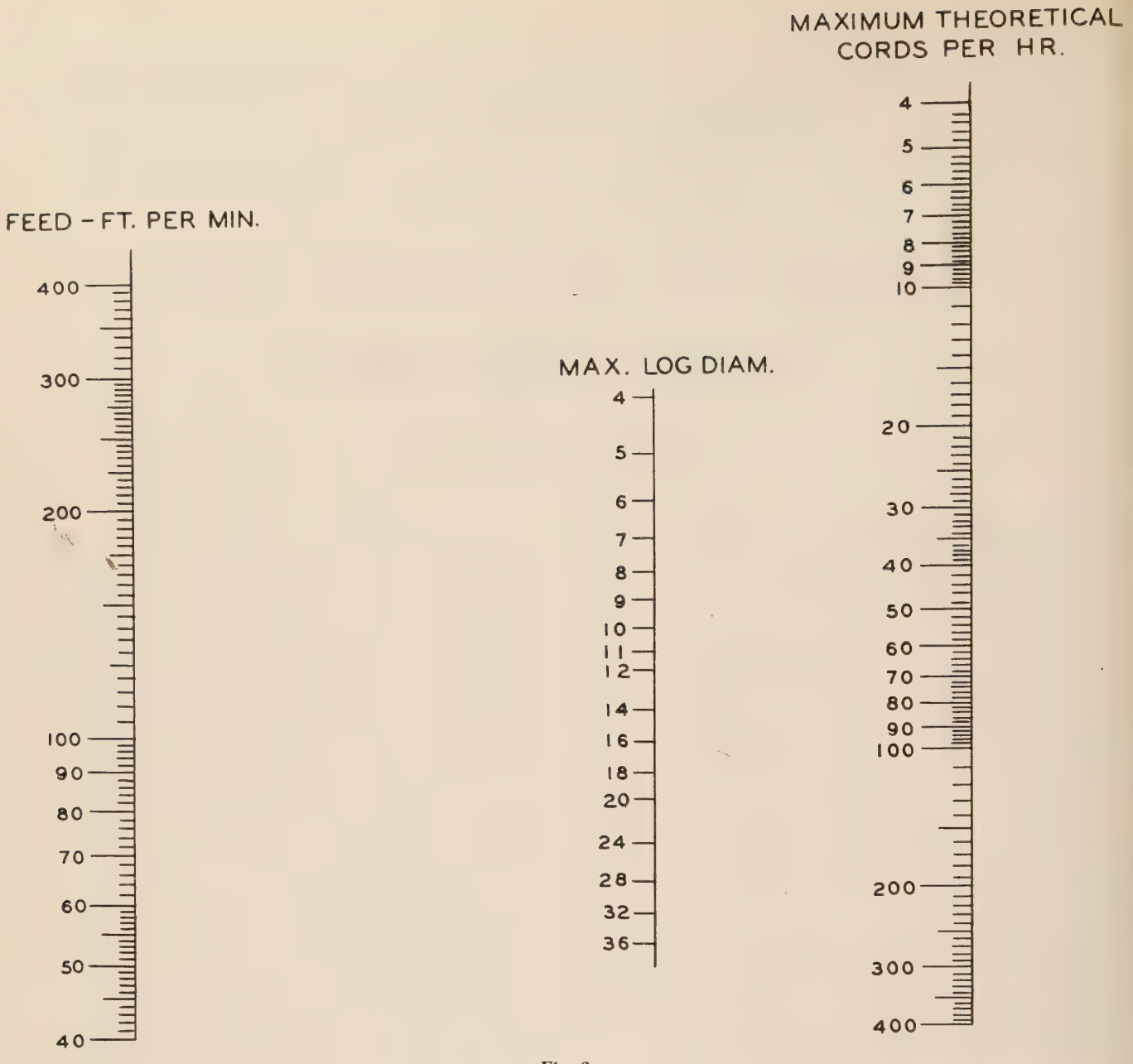


Fig. 2

If the chipper has a chip blower for conveying chips, this incremental power should be checked separately. If the chipper has a blower and a wound rotor motor drive, then care should be taken that the slow-down is not so great as to cause plugging of the ducts. Under such circumstances, some designers feel that the slow-down should not exceed 15% which is equivalent to 85% minimum speed.

A single formula can be used for calculating the drive horsepower requirement for a synchronous motor drive on those applications where the motor pull-out torque is the limiting factor.

$$\text{hp.} = \frac{SND^2LK \times 0.4}{3100}$$

N = number of knives
S = revolutions per minute
D = maximum log diameter, inches
L = length of chip, inches
K = horsepower-hours per cord

Note No. 1

The power system should be carefully studied if synchronous chipper motors are to be applied. The stored energy of the system should be great enough and the governing system quick enough to keep the rate of change of frequency at the bus less than about 0.6 cycle per sec. square. The maximum frequency deviation should be less than ±1.0 cycle per sec.

Note No. 2

Synchronous motors rated 250% pull-out torque and 0.8 power factor are the most economic synchronous motors for chipper application. Induction motor ratings are based on 250% breakdown torque characteristics and a maximum slip at breakdown of five times full load slip.

Note No. 3

In most cases when a chipper is driven by an induction motor, a lower motor horsepower can be applied than when the same chipper is driven by a synchronous motor.

Note No. 4

The cost of drive motors usually makes a belt drive more satisfactory than a direct drive for induction motors. Synchronous motor design considerations make it desirable in most cases to direct connect the synchronous motor to the chipper.

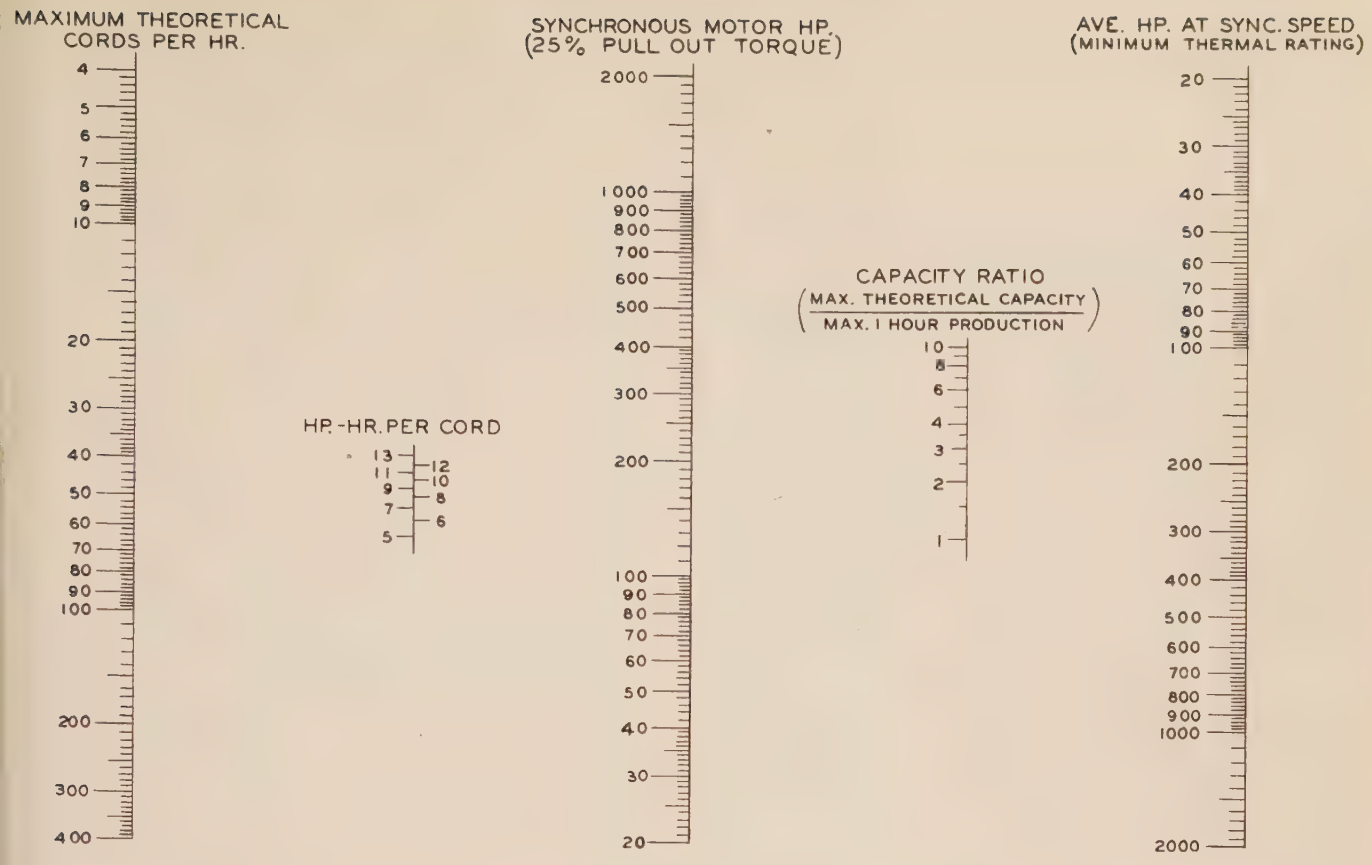

MAXIMUM THEORETICAL CORDS PER HR.
SYNCHRONOUS MOTOR HP. (25% PULL OUT TORQUE)
AVE. HP. AT SYNC. SPEED (MINIMUM THERMAL RATING)
HP.-HR. PER CORD
CAPACITY RATIO
(MAX. THEORETICAL CAPACITY / MAX. 1 HOUR PRODUCTION)

Fig. 3

Chipper Drive Selection—System No. 1

Section A—Data Pertaining to Chipper Characteristics and Production Requirements

Item			
1—Normal production		(Nonessential)	cords/hr.
2—Maximum 1 hr. production	Case 1	30	cords/hr.
	Case 2	100	cords/hr.
3—Wood species		Fir	
4—Horsepower-hour per cord (from Table I)		7	hp.-hr./cord
5—Maximum log length		$5^1/_4$	ft.
6—Average log diameter	Case 1–2	10	in.
	Case 3	7.25	in.
7—Spout diameter		19	in.
8—Maximum log diameter (spout diameter, 2)		17	in.
9—Total WR^2 (disk, sheave, and other parts)		72,000	p.s.i.
10—Disk diameter		Nonessential	in.
11—Number of knives		8	
12—Maximum chipper speed		400	r.p.m.
13—Maximum chip length		$^3/_4$	in.
14—Method of removing chips		assumed mechanical conveyor	

Section B—Calculations Involved in Selecting Ratings Either Synchronous or Induction Motors System No. 1

Item				
1—Chipper feed = ((A11) × (A12) × (A13))/12		=	200	f.p.m.
2—Maximum theoretical chipper capacity = (B1) × $(A8)^2$ × 0.00385		=	222.5	cords/hr.
3—(R_c), capacity ratio = (B2)/(A2)	Case 1	=	7.43	
	Case 2	=	2.22	
4—Peak power demand = (B2) × (A4)		=	1560	hp.
5—Required thermal rating = (B4)/(B3) or (A2) × (A4)	Case 1	=	210	hp.
	Case 2	=	700	hp.
6—(D_e), wood diameter required when fed end on end to meet 1 hr. maximum production rate = (A8) − VB_2	Case 1	=	6.26	in.
	Case 2	=	11.5	in.
7—Cords per log (maximum permissible diameter full length) = ((A5) × $(A8)^2$) 15,600		=	0.0974	cord/log
8—Energy required to chip one log (maximum diameter full length) = (A4) × (B7)		=	0.68	hp.-hr.
9—Stored energy = $\frac{(A9) \times (A12)^2}{3.2 \times 10^6 \times 3600}$		=	1.0	hp.-hr.
10—(R_e), energy ratio = (B8)/(B9) = $\frac{\text{energy to chip maximum diameter full length log}}{\text{stored energy}}$		=	0.68	

Section C—Rating Selection System No. 1

For Synchronous Motors:

Where R_e (item B3) is equal to or greater than 2.5, select rating in accordance with equation 1.

Where R_e (item B3) is less than 2.5, select rating in accordance with equation 2.

For Induction Motors:

Refer to nomograph (Fig. 1) giving relation between factors: (R_e), (R_c), and (S) and determine a value of S required to meet calculated values of R_e (item B10) and R_c (item B3) for each particular application.

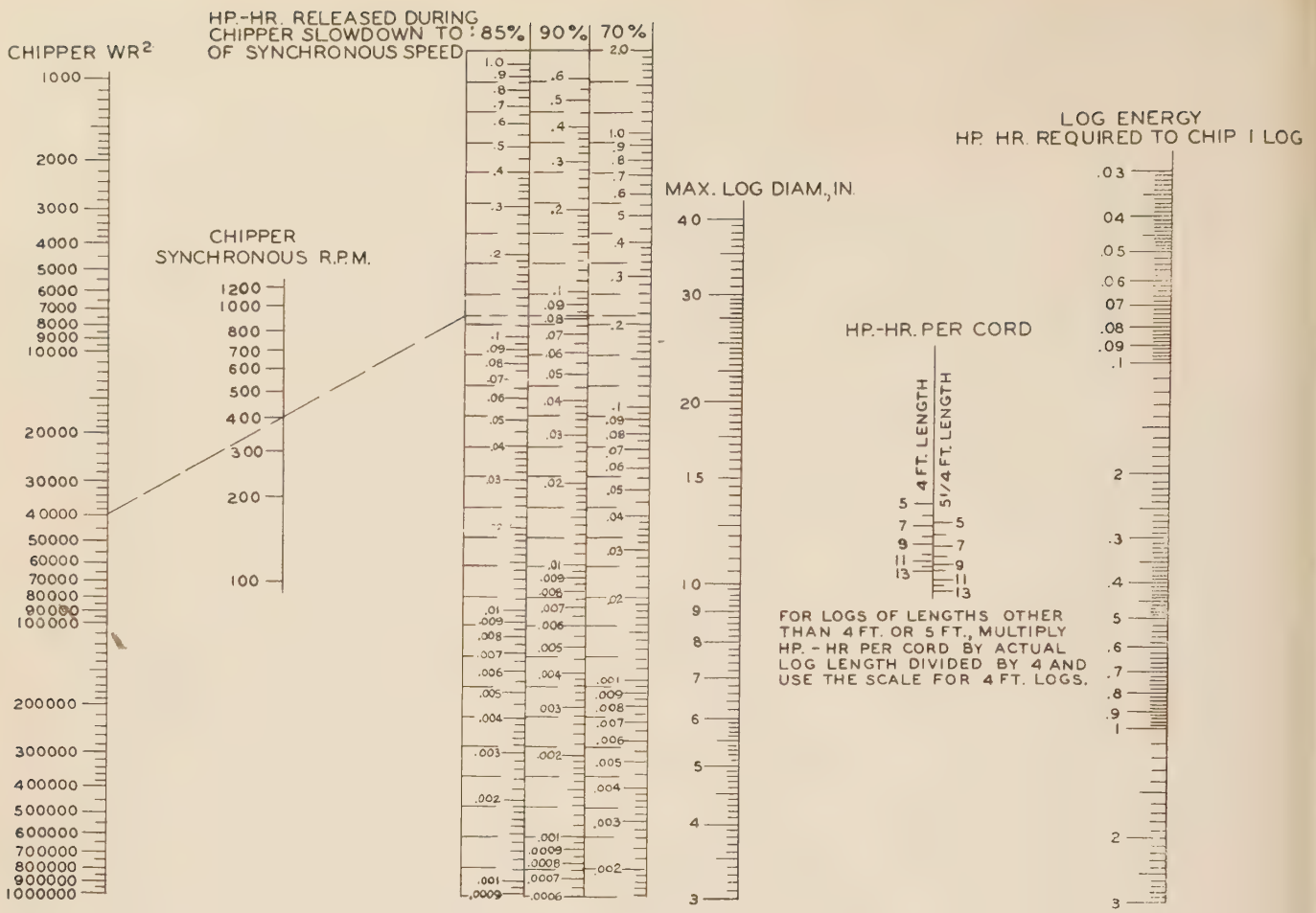

CHIPPER WR²
HP.-HR. RELEASED DURING CHIPPER SLOWDOWN TO % OF SYNCHRONOUS SPEED
85%
90%
70%
CHIPPER SYNCHRONOUS R.P.M.
MAX. LOG DIAM., IN.
HP.-HR. PER CORD
4 FT. LENGTH
5 1/4 FT. LENGTH
FOR LOGS OF LENGTHS OTHER THAN 4 FT. OR 5 FT., MULTIPLY HP.-HR PER CORD BY ACTUAL LOG LENGTH DIVIDED BY 4 AND USE THE SCALE FOR 4 FT. LOGS.
LOG ENERGY
HP. HR. REQUIRED TO CHIP 1 LOG

Fig. 4

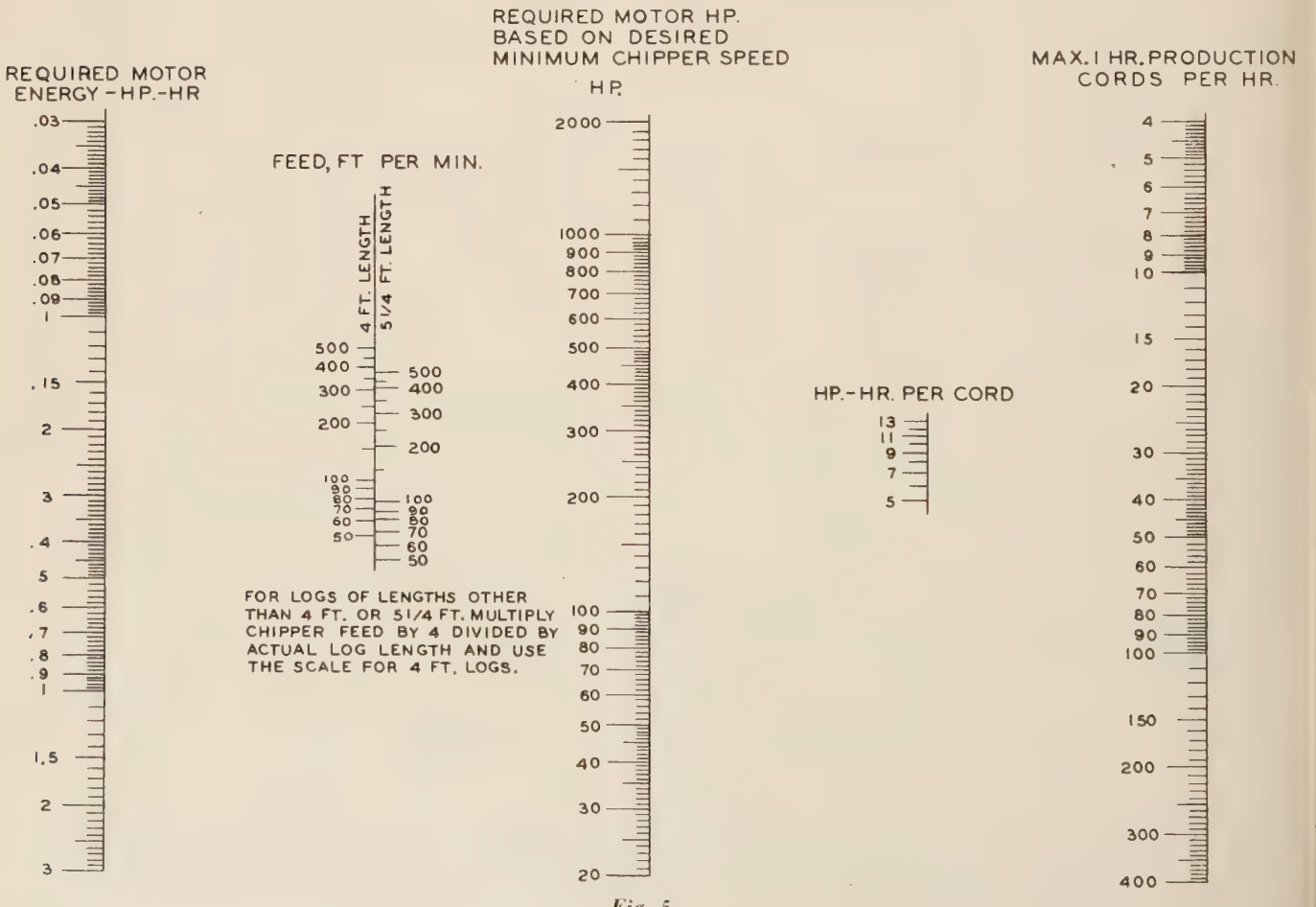

REQUIRED MOTOR ENERGY - HP.-HR
REQUIRED MOTOR HP. BASED ON DESIRED MINIMUM CHIPPER SPEED
HP.
FEED, FT PER MIN.
4 FT. LENGTH
5 1/4 FT. LENGTH
FOR LOGS OF LENGTHS OTHER THAN 4 FT. OR 5 1/4 FT. MULTIPLY CHIPPER FEED BY 4 DIVIDED BY ACTUAL LOG LENGTH AND USE THE SCALE FOR 4 FT. LOGS.
HP.-HR. PER CORD
MAX. 1 HR. PRODUCTION CORDS PER HR.

Fig. 5

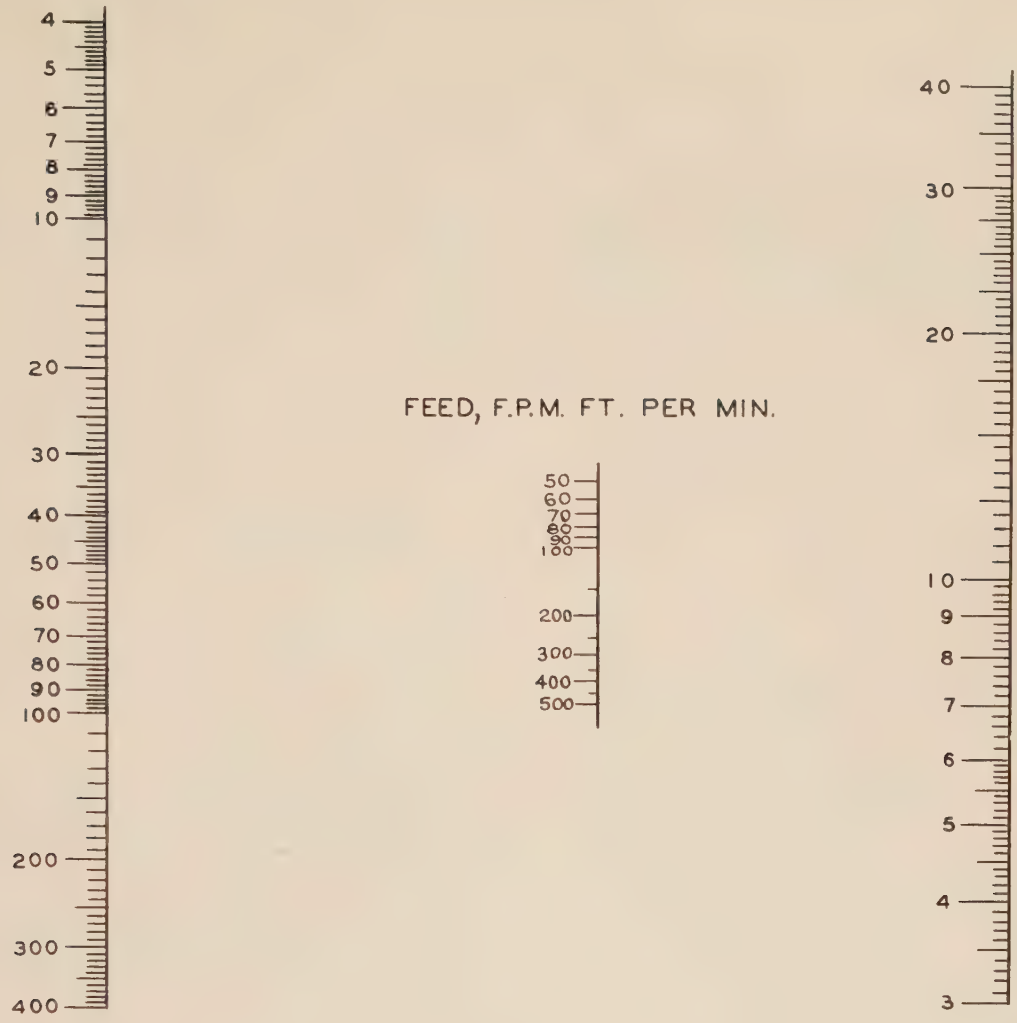


Fig. 6

Chipper Drive Selection—System No. 1—*Continued*

(a) If the required full load slip is between 4 and 6%, select wound rotor induction motor in accordance with equation 3 modified as per note (1).

(b) If the required full load slip is between 2 and 4%, select wound rotor motor or high slip squirrel cage motor rating in accordance with equation 3 modified as per note (1).

(c) If the required full load slip is 2% or less, select wound rotor motor or standard squirrel cage motor rating in accordance with equation 3 modified as per note (1).

(d) If the required full load slip exceeds 6% corresponding to a minimum operating speed of 70%, then obtain a modified value of R_c corresponding to 6% slip for the established value of R_e, and select motor rating in accordance with equation 4 modified as per note (1).

Horsepower (rating) is equal to or greater than (B4)/2.5	_____ hp.	(1)
Horsepower (rating) is equal to or greater than (item B5)	_____ hp.	(2)
For cases (a), (b), (c): induction motor rating = (B4)/(B3)	_____ hp.	(3)
For case (d): wound rotor induction motor rating = (B4)/R_c (modified)	_____ hp.	(4)

Note (1)—In all cases of induction motor applications, the average log diameter (item A6) must be checked against the end-on-end diameter (item B6) as calculated using R_c or (R_c modified). Where the average diameter is greater than D_e then the motor rating must be increased by the ratio (average diameter)/D_e.

Example Using System No. 1

To illustrate the recommended procedure in system no. 1 for selecting either synchronous or induction motor ratings, let us take typical examples:

B4 —Peak power demand—1560 hp.
B3 —Chipper capacity ratio (R_c) Ex. 1—7.43
Ex. 2—2.22
B10—(R_e) Energy ratio = 0.68
A6 —Average diameter Ex. 1-2-3-4-6 = 10 in.
Ex. 5 = 7.25 in.
A2 —Maximum production Ex. 1-3-4-5-6 = 30 cords/hr.
Ex. 2 = 100 cords/hr.

Synchronous Motor Rating:

Ex. 1—R_c greater than 2.5, hp. rating = 1560/2.5 = 625 hp.; select nearest standard.
Ex. 2—R_c less than 2.5, hp. rating = 100 × 7 = 700 hp.

Induction Motor Rating:

(From nomograph)
Ex. 3—R_c = 7.43, D_e 6.26, 30 cords/hr., 7.4% slip, 63% min. speed, av. diameter 10 in.
Horsepower rating (wound rotor) = 1560/7.43 × 10/6.26 = 334 hp.; select nearest standard, 350 hp.
(From nomograph)
Ex. 4—R_c (modified) 5.5, D_e 7.25, 6% slip, 70% min. speed, av. diameter 10 in.
Horsepower rating (wound rotor) = 1560/5.5 × 10/7.25 = 390 hp.; select nearest standard, 400 hp.
Ex. 5—With average diameter = 7.25 instead of 10, then horsepower rating (wound rotor) = 1560/5.5 × 7.25/7.25 = 280 hp.; select nearest standard, 300 hp.
Ex. 6—With special case limiting induction motor slip to 2% with standard squirrel cage design.
(From nomograph)
R_c = 2.85, D_e10, 2% slip, 90% minimum speed, av. diameter 10 in.
Horsepower rating (squirrel cage) = 1560/2.85 × 10/10 = 550 hp.; select nearest standard, 600 hp.

Chipper Drive Selection—System No. 2

Chipper Calculation Form—Synchronous Motor

1. Chipper = 400 r.p.m.
2. Number of chipper knives = 8
3. Chip size = $^3/_4$ in.
4. Feed = revolutions per minute × knives × $\frac{\text{chip length}}{12}$ inches = 200 f.p.m.
5. Maximum log diameter 17 in. (spout diameter minus 2 in.)
6. Maximum theoretical cords per hour (Fig. 2) = 220
7. Horsepower-hours per cord (selected in accordance with wood species) = 7
8. Nominal horsepower = (Fig. 3) = 600
9. Capacity ratio = $\frac{\text{maximum theoretical cords per hour}}{\text{maximum production rate (1 hr. peak production)}}$ = $\frac{220}{30}$ = 7.33
10. Thermal horsepower demand (Fig. 3) = 208
    Required motor size is the larger of the values obtained in line 10 = 600

Chipper Calculation Form—Induction Motor

1. Chipper (synchronous speed) = 400 r.p.m.
2. Number of chipper drives = 8
3. Chip size = $^3/_4$ in.
4. Feed = revolutions per minute × knives × $\frac{\text{chip length}}{12}$ = 200 f.p.m.
5. Chipper WR^2 = 72,000
6. Desired minimum chipper speed after chipping maximum diameter log
   - Normal slip squirrel cage motor, 1 to 2% slip; Wound rotor motor, no external resistance } 90% speed
   - High slip squirrel cage motor, 3 to 4% slip; Wound rotor motor, 2 to 3% external resistance } 85% speed
   - Very high slip squirrel cage motor, 5 to 8% slip; Wound rotor motor, 4 to 6% external resistance } 70% speed
7. Chipper energy released in chipping maximum log (Fig. 5) = 0.38
8. Maximum log diameter = 17 in.
9. Horsepower-hours per cord (selected in accordance with wood species) = 7
10. Length of log = $5^1/_4$ ft.
11. Energy consumed in chipping maximum diameter log (Fig. 5) = 0.68
12. Required energy from motor (line 11 minus line 7) = 0.3
13. Required motor based on minimum chipper speed of 70% (Fig. 6) = 370
14. Maximum production rate (maximum rate for 1 hr.) = 30 cords/hr.
15. Required motor based on required maximum production rate (Fig. 6) = 208
    Required motor size is the larger of the values obtained in line 13 or line 15 = 400
16. Average log diameter required to meet maximum production rate based on logs being fed end on end (Fig. 6) = 6.2 in.

RECENT BOOKS

Industrial Detergency. By William W. Niven, Jr., Midwest Research Institute, Kansas City, Mo. Reinhold Publishing Corp., New York, 1955. Cloth, 6 × 9, 340 pages.

In accord with current practice "Industrial Detergency" has been prepared by a number of specialists who deal with the composition of detergents; how they are used; factors determining their choice for specific uses; evaluation of results; and trends in detergent research.

Although the book does not deal specifically with the paper industry it covers the fundamentals and deals specifically with the laundry, textile, foods, dairy, metals, and general industry. It is a useful compilation of data on the subject.

Nomography and Empirical Equations. By Dale S. Davis, Virginia Polytechnic Institute. Reinhold Publishing Corp., New York, 1955. Cloth, 6 × 9, 235 pages. $6.75.

Mr. Davis has written several books and articles on this subject. At one time he was the mathematician for the Mead Corp. and began his work in his specialty in the pulp and paper industry. Many readers of *Tappi* are acquainted with his work.

Part I explains the development of empirical equations for two and three variable data. The second part deals with curve fitting and nomography to show how time-saving techniques can be developed. The book is of particular value to research workers.

Protective Coatings for Metals, 2nd Ed. By R. M. Burns and W. W. Bradley, Bell Telephone Laboratories. Reinhold Publishing Corp., New York, 1955. Cloth, 6 × 9, 643 pages. $12.

The new second edition of ACS Monograph No. 129 has been prepared for corrosion engineers and chemists and others responsible for plant equipment protection.

Among the subjects covered are corrosion control, surface preparation of coatings, types of metallic coatings, sprayed metal coatings, zinc coatings, nickel and chromium, organic coatings, anodized coatings, special-purpose coatings and corrosion inhibitors.

The book is a worthy contribution to the current effort to minimize the great plant losses due to corrosion.

Industrial Purchasing. By J. H. Westing and I. V. Fine, University of Wisconsin. John Wiley & Son, New York, 1955. Cloth, 6 × 9, 421 pages. $7.50.

The authors prepared this book in cooperation with the Milwaukee Association of Purchasing Agents. An attempt is made through the book to stress matters of policy and broad procedure. The subject matter was based on a large number of discussions by the industrial purchasing agents in Milwaukee.

Among the subjects covered were the procedures, forms, and records of purchasing; selecting sources of supply, quality control, price determination, traffic, scrap disposal, forward buying, legal aspects, personnel management, reports to management, evaluation of performance, major equipment. A chapter is devoted to the purchase of paper and the bases of selection.

Techniques of Plant Maintenance and Engineering—1955. Clapp & Poliak, Inc., 341 Madison Ave., New York, 1955. Cloth, 8½ × 11, 218 pages. $7.50.

The Proceedings of the Technical Sessions held concurrently with the Sixth National Plant Maintenance and Engineering Show held at Chicago in January 1955 is a continuation of the series of books featuring the papers presented at previous meetings and reviewed in earlier issues of *Tappi*. Each chapter is prepared by a different author, each considered to be an expert in his field.

Among the subjects covered are Maintenance and Construction of Plant Buildings; Control of Maintenance Activities in the Process Industries; Organization of the Maintenance Force; Maintenance Cost Control; Work Measurement and Work Standards; Preventive Maintenance Within Balanced Maintenance; Training the Maintenance Force; Planning and Scheduling; Worker Motivation; Getting Along with Unions.

In addition there is a report of the round-table discussions on electronic control equipment, electrical distribution systems, corrosion control, lubrication, maintenance stores, safety and fire protection, power plant equipment, maintenance manuals, paper mills, and paper products plants.

Case Studies in Industrial Management. By J. M. Juran, Consultant and N. N. Barish, New York University. McGraw-Hill Book Co., New York, 1955. Fabricoid-loose-leaf, 8½ × 11, 230 pages. $5.

This book aims to approximate a laboratory for a course in industrial management. It depicts in detail the operation of a single company, Burndy Engineering Co. The various sections show how this company designs, makes, and sells its product; how it conducts personnel relations; how it controls its costs, schedules, and quality; how it plans to manufacture; how it repairs its equipment; how it finances, organizes, and coordinates its activities. More than 100 members of the Burndy organization were interviewed by the authors. It is the first book of its kind dealing completely with the management of a single company in all aspects.

Patent Law in the Research Laboratory. By John K. Wise. Reinhold Publishing Corp., New York, 1955. Cloth, 4½ × 6¾, 145 pages. $2.95.

The present volume is the fourth in the series of Reinhold Pilot Books which are intended to supply information desired by engineers and technical dealing with a new art or new technology. Although they are comparatively brief they are complete in essential information and written to be understandable to the nonexpert. This book gives the industrial research worker a practical insight into the workings of the patent system.

It describes how patent rights may be acquired, preserved, or lost by ordinary routine-seeming daily conduct and shows how a research worker can work effectively with his patent counsel.

Sizing Up People. By Donald A. Laird and Eleaner C. Laird. McGraw-Hill Book Co., New York, 1955. Cloth, 5½ × 8, 270 pages. $4.

Previous books written by the authors may be familiar to a large number of readers of *Tappi*. It is a book devoted to psychological methods of judging people. It shows how people differ, how human abilities are grades, brain power and intelligence, the primary mental abilities, mechanical and engineering abilities, glands and personality estimating trust worthiness, telltale personality indicators, etc.

Organic Chemistry Simplified 2nd Ed. By R. Macy, formerly of the University of Maine. Chemical Publishing Co, New York, 1955. Cloth, 5½ × 8½, 611 pages. $12.

Progress over the years led the author to rewrite and bring up to date his novel arrangement of the text. Emphasis in the second edition is devoted to the electron theory. It differs from the usual text which is usually based on a classification of aliphatic and aromatic compounds of carbon.

The first part features valence. In the second part the so-called architecture of carbon compounds is illustrated. The classification of carbon compounds follows in the third part and the fourth part deals with special topics of organic chemistry such as proteins, carbohydrates, sugars, dyes, isotopic chemistry, and giant molecules.

Mathematics for the Chemist. By G. J. Kynch, University of Wales. Academic Press, New York, 1955. Cloth, 5½ × 8½, 356 pages. $4.80.

The purpose of the author is to help chemists, physicists, and chemical engineers to decide when a particular mathematical method can be applied to a problem and when it cannot do so.

Among the subjects covered are approximate solution of equations, sequences and limits, differentiation, rational functions, circular functions, exponential, logarithmic, and hyperbolic functions, properties of curves, integration, complex members, functions of several variables, surface and volume distribution, determinates, and vectors.

Although the text is not elementary in nature the author recognizes that most chemists and engineers have not studied mathematics to the extent that they should and therefore tempers the text to embrace the average knowledge of a graduate of a technical university.

Information Processing Equipment. Edited by M. P. Doss, The Texas Co. Reinhold Publishing Corp. New York, 1955. Cloth, 6 × 9½, 270 pages. $8.75.

Mr. Doss is Chairman of the Division of Chemical Literature of the American Chemical Society and for more than thirty years has been technical librarian of the Research and Technical Department of the Texas Co. The book is the first text ever published on the subject in a single volume. Individual chapters are prepared by experts on the subjects.

Among the subjects covered are: Special Typing, Stenciling, Hectographing, Figure Preparation and Miscellaneous Equipment; Lensless Copying with Sensitized Papers; Photography in the Laboratory, Microcopying, Xerography; Letterpress and Offset Printing; Authors Guide to Effective Slides-Projection Equipment; Audio Methods for Handling Data; Storing and Finding Technical Data with Punched Cards; and Numerical Data-Handling Machines.

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The volume is literally a handbook on ways of collecting and storing information.

The Biltmore Story. By Carl A. Schenk. St. Paul American Forest History Foundation, Minnesota Historical Society. 1955. Cloth, 6 × 9½, 224 pages. $3.95.

The American Forest History Foundation is entitled to congratulations for encouraging Carl Schenk to write his memoirs relating to the beginnings of forestry in the United States. Mr. Schenk came to America in 1895 to take over the management of the woodlands of George W. Vanderbilt near Asheville, N. C. The text prepared by Mr. Schenk was edited by Arvid Butler, formerly executive director of the American Forestry Association. There are a number of graduates of the famous Biltmore School in the pulp and paper industry. The book should find a place in every paper mill library.

Manufacture & Application of Lubricating Greases. By C. J. Boner, Chief Research Chemist, Battenfeld Grease & Oil Corp. Reinhold Publishing Corp., New York. Cloth, 6 × 9, 980 pages. $18.50.

The reasons for this book are well set forth in the preface as follows: "Nearly a score of years has passed since the publication of a comprehensive book on lubricating greases. In the meantime, great improvement has been made in such products, and a large proportion of the lubricating greases now manufactured consist of types not perfected a few years ago. Improvement in processing and equipment has kept pace with or preceded that of the finished product. Likewise, the theory of structure and application of lubricating greases has received considerable attention within the past ten years."

The author is well qualified by background, experience and reputation to discuss the field. This book is a much needed reference source in a field which has long been lacking such a standard work. It should be useful to mechanical engineers in all types of industry which have lubrication problems. The author has very carefully checked other authorities in the field and the reader is referred to the Preface.

The book contains a very complete Table of Contents which goes far beyond the usual form. It is thus helpful in deciding which parts to read. The twenty-three chapters are as follows: Introduction; Structure and Theory; Additives Other Than Structure Modifiers; Raw Materials; Manufacturing Process; Equipment for Lubricating Grease Manufacture; Aluminum Base Lubricating Greases; Barium Base Lubricating Greases; Calcium Base Lubricating Greases; Lithium Base Lubricating Greases; Sodium Base Lubricating Greases; Lead Soap Lubricating Greases; Strontium Base Lubricating Greases; Miscellaneous Metal Soaps as Components of Lubricating Greases; Mixed Base Lubricating Greases; Complex Soap Lubricating Greases; Non-Soap Thickeners for Lubricating Fluids; Fillers in Lubricating Greases and Solid Lubricants; Residua and Petrolatums as Lubricants; Analysis of Lubricating Greases; Tests of Lubricating Greases and Their Significance; Application of Lubricating Greases; Trends in Lubricating Greases.

This work has an excellent coverage of the lubricating grease field. It should fill a real need in compounding, manufacturing and in the application of lubricating greases. The book should be extremely helpful to lubrication engineers in the pulp and paper industry. It should assist in a better understanding of lubricating greases and in their proper use and application. JOHN B. CALKIN

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E316-55. Research Chemist, Ph.D., with ten years' experience in research and development work within the pulp and paper industry desires the position of Technical Adviser or Technical Director. Particularly well versed in wood utilization, pulping and bleaching processes.

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P486-55. Technical Sales Engineer—Graduate with experience in clay filler and coating field to join staff of well established, progressive, highly reputable raw material producer headquartered in the East. Excellent oportunity for technical or production man wishing to enter sales field and to assist development of new department. Send photograph, résumé including personal data, education, experience and salary requirements. Replies will be confidential.

MISCELLANEOUS

A13-55. Are your Mullen tester readings correct? Standardized aluminum foil in ranges 10–15, 25–35, 40–50, and 55–65 lb. available from Testing Foil Service, 304 N. Stevens St., Rhinelander, Wis.

MARKET DEVELOPMENT

Excellent opportunity for paper chemist preferably with experience in promotion or sale of latices to paper industry with progressive established chemical company. Send complete résumé including expected salary, education, and experience. All replies will be kept confidential. Send replies to *Tappi*, P483-55, 155 East 44th St., New York 17, N. Y.

Paper Technologist for Pigment Technical Service

Pigments Division of large national chemical manufacturer requires services of B.S., M.S., or Ph.D. chemist or chemical engineer with broad paper mill experience for field technical service work on application of pigments in paper manufacture. Sales potential and willingness to travel essential. Age 30–40, New York Metropolitan area headquarters. Please submit complete résumé to *Tappi*, P484-55, 145 East 44th St., New York 17, N. Y.

TECHNICAL SALESMAN

National Supplier to the pulp and paper industry needs a top man to sell quality products to this industry. Experience in paper manufacturing preferred. Will consider training chemist or chemical engineer without paper experience if he is strong in sales ability. Salary, company car, expenses paid, liberal employee benefits. This is a career job. Please send complete details. All replies confidential. Send to *Tappi*, P485-55, 155 East 44th Street, New York 17, N. Y.

SALES MANAGER

Small manufacturer of papermaking felts in New England needs a sales manager. Appropriate technical experience in paper industry required. Excellent opportunity in a progressive, developing company. Salary $12,000 to $15,000. Send application or résumé to Stevenson, Jordan and Harrison, Inc., Department PE, 19 West 44th St., New York, N. Y. (Do not telephone.)

Note: Responses to all advertisements should, unless otherwise indicated, be sent to TAPPI, 155 E. 44th St., New York, N. Y.

PAPER CHEMIST

Paper Chemist for research and development with a large electronics division of General Motors. The position is permanent and many desirable benefits are offered, such as: location in progressive and pleasant Indiana city, excellent working conditions, outstanding G.M. employee benefits, and a good starting salary. A degree in chemistry or chemical engineering, and 5 years experience in paper industry required.

Reply to TAPPI, P476-55, 155 E. 44th St., New York 17, N. Y.

LOCAL SECTION ACTIVITIES

Reports of Meetings, Personnel and Events

Officers of Local Sections

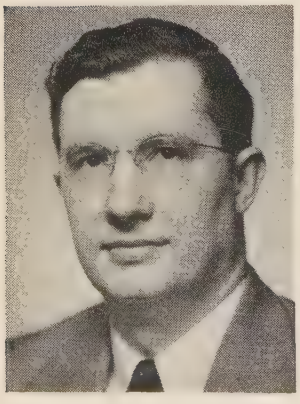
Following a Summer recess, during which, the local sections of the Technical Association hold business meetings to prepare meeting programs for the 1955–56 season, they are ready to start their new year with new executive organizations and meeting schedules. Meetings are held by most of the sections from September until June at which time the officers for the next season are elected. The officers and executive committeemen who were elected to serve for the 1955–56 terms are as follows:

Pacific

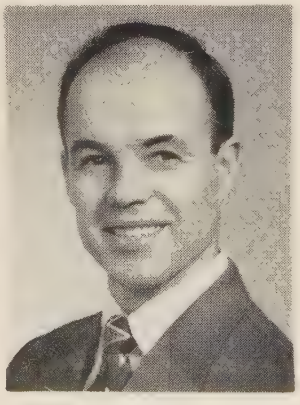
Chairman—J. M. McEwen, Weyerhaeuser Timber Co., Everett, Wash.
Vice-Chairman —B. T. Briggs, Rayonier, Inc., Shelton, Wash.
Secretary-Treasurer—R. H. Smythe, Ray Smythe Co., Portland, Ore.
Executive Committee—Officers and H. B. Petersen, Hercules Powder Co., Portland, Ore.; K. G. Booth, Crown Zellerbach Corp., Camas, Wash.; Norval Magnusson, Puget Sound Pulp & Timber Co., Bellingham, Wash.; S. P. Strayer, St. Regis Paper Co., Tacoma, Wash.
Past-Chairmen—C. R. P. Cash, R. S. Wertheimer, C. W. Morden, R. B. Hansen, Lawrence Killam, M. W. Black, W. R. Barber, F. A. Olmsted, Carl Fahlstrom, G. H. McGregor, N. W. Coster, C. E. Braun, E. P. Wood, C. A. Enghouse, Erik Ekholm, H. W. Bialkowsky, G. H. Gallaway, J. L. McCarthy, H. C. Wall, W. F. Holzer, R. I. Thieme, E. O. Ericsson, S. E. Hazelquist, F. J. Weleber, and E. H. Nunn.
National Executive Committee Representative—E. O. Ericsson, Puget Sound Pulp & Timber Co., Bellingham, Wash.

Lake States

Chairman—S. R. Parsons, Consolidated Water Power and Paper Co., Wisconsin Rapids, Wis.
Vice-Chairman—S. J. Baisch, Thilmany Pulp and Paper Co., Kaukauna, Wis.
Secretary—D. J. MacLaurin, Gilbert Paper Co., Menasha, Wis.
Treasurer—W. J. Bublitz, Kimberly-Clark Corp., Neenah, Wis.
Executive committee—Officers and L. A. Moss, Whiting Plover Paper Co., Stevens Point, Wis.; J. R. Salvesen, Marathon Corp., Rothschild, Wis.; J. W. Bard, Marathon Corp., Green Bay, Wis.; R. L. Leaf, Jr., Shawano Paper Mills, Shawano, Wis.
Past-Chairmen—G. K. Hill, Otto Kress, R. J. LeRoux, A. T. Gardner, S. D. Wells, J. R. Fanselow, H. W. Morgan, E. H. Voightman, R. A. Nugent, M. L. Downs, N. L. Malcove, J. H. Graff, T. R. Probst, J. P. Weidner, H. P. Dixson, L. V. Forman, C. J. West, Jr., A. M. Heald, G. R. Sears, H. C. Crandall, A. P. Adrian, H. W. Rowe, Robert J. Seidl, L. A. Moss.
National Executive Committee Representative—J. C. Wollwage, Kimberly-Clark Corp., Neenah, Wis.



J. M. McEwen, Weyerhaeuser Timber Co.; Chairman, Pacific Section



P. E. Nethercut, Scott Paper Co.; Chairman, Delaware Valley Section

Delaware Valley

Chairman—Philip E. Nethercut, Scott Paper Co., Chester, Pa.
First Vice-Chairman—C. R. Calkins, Reigel Paper Corp., Milford, N. J.
Second Vice-Chairman—C. F. Ackerman, Union Mills Paper Mfg. Co., New Hope, Pa.
Treasurer—D. C. Kane, Paper Makers Chemical Dept., Hercules Powder Co., Wilmington, Del.
Secretary—George K. Boger Jr., Paper Products Mfg. Co., Swarthmore, Pa.
Executive Committee—Officers and Frank J. Lovegren, P. H. Glatfelter Co., Spring Grove, Pa., and Emil R. Padavic, Container Corp., of America, Manayunk, Pa.
Past-Chairmen —W. R. Maull, G. E. Landt, H. P. Cannon, H. C. Schwalbe, J. d'A. Clark, C. M. Connor, E. J. Albert, J. D. Davis, W. M. Shoemaker, A. L. M. Bixler, John Macadam, J. P. Weidner, A. S. Erspamer, H. C. Brill, F. J. Lovegren, and E. R. Padavic.
National Executive Committee Representative—J. D. Lyall, Armstrong Cork Co., Lancaster, Pa.

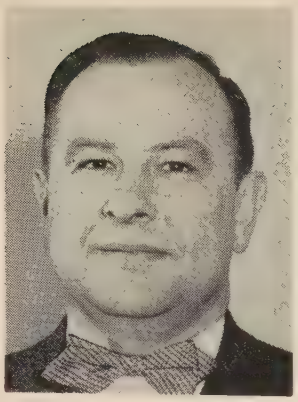
Kalamazoo Valley

Chairman—R. T. Trelfa, Watervliet Paper Co., Watervliet, Mich.
Vice-Chairman—R. T. Elias, Western Michigan College, Kalamazoo, Mich.
Secretary—P. D. Applegate, Hercules Powder Co., Kalamazoo, Mich.
Treasurer—H. R. Hall, Allied Paper Mills, Kalamazoo, Mich.
Executive Committee—Officers and O. W. Callighan, Minerals & Chemicals Corporation of America, Kalamazoo, Mich.; H. L. Vanderberg, A. E. Staley Manufacturing Co., Kalamazoo, Mich.; W. E. Caldwell, St. Regis Paper Co., Kalamazoo, Mich.; N. K. Plantefaber, R. T. Vanderbilt Co., Inc., Kalamazoo, Mich.; E. E. Stephenson, Jr., Sutherland Paper Co., Kalamazoo, Mich.; C. E. Mueller, Lockport Felt Co., Kalamazoo, Mich.; and John Lean, Rex Paper Co., Kalamazoo, Mich.
Past-Chairmen—M. D. Bardeen, E. F. Whittington, H. C. Bradford, C. C. Schneider, H. M. Annis, M. R. Wilkins, W. F. Hathaway, P. de Guehery, W. A. Kirkpatrick, F. L. Chappell, F. D. Elliott, F. R. Hamilton, E. B. Taylor, R. C. Germanson, R. T. Mashburn, L. H. Mimms, P. W. Batholomew, S. I. Kukolich, J. J. Harrison, J. R. Dam, A. T. Luey, R. H. Hurst, and J. A. Dean.
National Executive Committee Representative—R. L. Davis, Scott Paper Co., Detroit, Mich.

New England

Chairman—G. L. Benson, St. Regis Paper Co., E. Pepperill, Mass.
Vice-Chairman —C. L. Reese, Westfield River Paper Co., Russell, Mass.
Secretary-Treasurer—R. W. Ramsdell, Hercules Powder Co., Holyoke, Mass.
Executive Committee—Richard Dempsey, A. E. Staley Mfg. Co., So. Hadley Falls, Mass.; P. J. Fitzpatrick, American Cyanamid Co., Boston, Mass.; C. I. Horton, Philadelphia Felt Co., Norwalk, Conn.; Miss Helen U. Kiely, American Writing Paper Co., Holyoke, Mass.; F. S. Klein, Byron Weston Co., Dalton, Mass.; John Lewis, Lowell Technological Institute, Lowell, Mass.; J. T. Loomer, Robert Gair Co., Uncasville, Conn.; Ronald Mallock, American Writing Paper Co., Holyoke, Mass.; F. L. Simons, Crane & Co., Dalton, Mass.; Wm. Stillman, Bird & Son, E. Walpole, Mass.; and E. W. Strecker, Esleek Mfg. Co., Turners Falls, Mass.
Past-Chairmen—F. C. Clark, R. C. Griffin, J. B. Calkin, R. H. Doughty, N. I. Bearse, W. L. Foote, L. B. Tucker, C. H. Child, P. S. Bolton, R. J. Proctor, H. W. Knudson, and F. S. Klein.

R. T. Trelfa, Watervliet Paper Co.; Chairman, Kalamazoo Valley Section



W. H. Aiken, Gardner Board and Carton Co.; Chairman, Ohio Section

National Executive Committee Representative—N. I. Bearse, Champion-International Co., Lawrence, Mass.

Ohio

Chairman—Wm. H. Aiken, Gardner Board and Carton Co., Middletown, Ohio
Vice-Chairman—Ellsworth H. Shriver, The Mead Corp., Chillicothe, Ohio
Corresponding Secretary—Frank C. Duvall, Shartle Brothers, Middletown, Ohio
Recording Secretary—Virgil Perry, Harding-Jones Paper Co., Middletown, Ohio
Treasurer—George B. Gregg, Cincinnati Gas & Electric Co., Cincinnati, Ohio
Executive Committee—Officers and H. R. Joiner, Champion Paper & Fibre Co., Hamilton, Ohio; J. L. Clouse, Oxford Miami Paper Co., West Carrollton, Ohio; C. E. Brandon, Howard Paper Mills, Inc., Dayton, Ohio; H. A. Smith, The Mead Corp., Chillicothe, Ohio; Donald F. Jenkins, Champion Paper & Fibre Co., Hamilton, Ohio; and Edward W. Petrich, Howard Paper Mills, Inc., Dayton, Ohio.
Past-Chairmen—V. F. Waters, H. H. Latimer, K. P. Geohegan, J. E. Burdsell, H. C. Fisher, C. D. Roess, S. I. Olsen, D. M. Yost, P. S. Cade, Arthur Thurn, D. J. Goodman, H. A. Smith, C. E. Brandon, J. L. Clouse, and H. R. Joiner.
National Executive Committee Representative—D. J. Goodman, Sorg Paper Co., Middletown, Ohio

Empire State

Chairman—W. R. Willets, Titanium Pigment Co., New York, N. Y.
First Vice-Chairman—G. K. Storin, Niagara Alkali Co., Niagara Falls, N. Y.
Second Vice-Chairman—G. G. Cole, Finch, Pruyn & Co., Glens Falls, N. Y.
Third Vice-Chairman—J. W. Morrow, Newton Falls Paper Co., Newton Falls, N. Y.
Secretary-Treasurer—R. N. Prince, Fort Orange Paper Co., Castleton, N. Y.
Executive Committee—Officers and L. R. Ayers, Robert Gair Co., Piermont, N. Y.; J. J. Forsythe, International Paper Co., Niagara Falls, N. Y.; D. B. Geffken, Oswego Falls Corp., Fulton, N. Y.; E. H. Johnson, Stevens & Thompson Paper Co., Greenwich, N. Y.; and R. A. Schwartz, Knowlton Bros. Co., Watertown, N. Y.
Past-Chairmen—J. H. Schuber, C. E. Libby, J. H. Rich, R. F. Huntley, F. C. Goodwill, H. D. Cook, F. J. Lang, W. O. Hisey, F. J. McCourt, H. A. Spencer, John Campbell, M. L. Jaffe, J. E. Foote, C. E. Foster, H. J. Perry, J. S. Reichert, R. M. Drummond, D. C. Mather, and F. G. Sommerville.
National Executive Committee Representative—C. J. Sibler, West Virginia Pulp & Paper Co., New York, N. Y.

Central District

Chairman—D. B. Geffken, Oswego Falls Corp., Fulton, N. Y.
Vice-Chairman—W. A. Holl, Victoria Paper Mills Co., Fulton, N. Y.
Secretary—Mrs. Barbara Wortley, Solvay Process Division, Syracuse, N. Y.
Treasurer—S. E. Church, College of Forestry, State University of New York, Syracuse, N. Y.

Eastern District

Chairman—E. H. Johnson, Stevens & Thompson Paper Co., Greenwich, N. Y.
Vice-Chairman—Vincent Long, American Wood Board Co., Greenwich, N. Y.
Secretary—Thomas McGreen, International Paper Co., Glens Falls, N. Y.
Treasurer—Clyde Davis, Jr., Finch, Pruyn & Co., Glens Falls, N. Y.

Metropolitan District

Chairman—L. R. Ayers, Robert Gair Co., Piermont, N. Y.
Chairman-Elect—J. H. Doherty, Union Bag & Paper Corp., New York, N. Y.
Secretary-Treasurer—W. A. Beeman, Socony-Vacuum Oil Co., New York, N. Y.

Northern District

Chairman—R. A. Schwartz, Knowlton Bros. Co., Watertown, N. Y.
Vice-Chairman—P. R. Anderson, St. Regis Paper Co., Deferiet, N. Y.
Secretary—Miss Elizabeth Case, Stebbins Engineering & Mfg. Co., Watertown, N. Y.
Treasurer—J. C. Parsell, J. P. Lewis Co., Beaver Falls, N. Y.

Western District

Chairman—J. J. Forsythe, International Paper Co., Niagara Falls, N. Y.
Vice-Chairman—R. H. Zinsmeister, Kimberly-Clark Corp., Niagara Falls, N. Y.
Secretary—H. E. Lindberg, Robert Gair Co., North Tonawanda, N. Y.
Treasurer—E. F. Andrews, International Paper Co., Niagara Falls, N. Y.

Maine-New Hampshire

Chairman—A. E. Jones, Oxford Paper Co., Rumford, Me.
Vice-Chairman—R. J. Martin, Fraser Paper Ltd., Madawaska, Me.
Secretary-Treasurer—H. E. Pratt, Pejepscot Paper Co., Brunswick, Me.
Executive Committee—Officers and A. E. Bachmann, Missisquoi Corp., Sheldon Springs, Vt.; C. T. Bockers, Eastern Corp., Bangor, Me.; A. J. Chase, University of Maine, Orono, Me.; P. M. Goodloe, Brown Co., Berlin, N. H.; J. H. Heuer, Great Northern Paper Co., Millinocket, Me.; H. S. Hooper, Penobscot Chemical Fibre Co., Great Works, Me.; E. N. Poor, Hudson Pulp & Paper Co., Augusta, Me.; F. N. Sprague, St. Regis Paper Co., Bucksport, Me.; J. J. Thomas, S. D. Warren Co., Cumberland Mills, Me., and J. F. Wright, National Aniline Division, Boston, Mass.
Past-Chairmen—W. E. Brawn, T. M. Barry, Clifford Patch, E. L. Lamb, J. L. Parsons, G. A. Day, and J. J. Thomas.
National Executive Committee Representative—J. J. Thomas, S. D. Warren Co., Cumberland Mills, Me.

Chicago

Chairman—A. C. Dreshfield, Chicago Testing Laboratory, Chicago, Ill.
Vice-President—Melvin Snover, Williamson Adhesive Co., Skokie, Ill.

C. L. Reese, Westfield River Paper Co., Vice-Chairman; G. L. Benson, St. Regis Paper Co., Chairman; F. S. Klein, Byron Weston Co., Past-Chairman; and R. W. Ramsdell, Hercules Powder Co., Secretary-Treasurer, New England Section

Secretary—Kazuo Horita, Container Corp. of America, Chicago, Ill.
Treasurer—R. L. Ueberbacher, American Maize Products Co., Roby, Ind.
Executive Committee—Officers and R. D. Carter, Keyes Fibre Co., Hammond, Ind.; Walter C. Daley, Daley Paper Co., Chicago, Ill.; J. D. Johnson, Container Corp. of America, Chicago, Ill.; C. S. Macnair, Acme Steel Products Co., Chicago, Ill.; A. L. Magnuson, Kelco Company, Chicago, Ill.; and R. W. Porter, Fibre Containers, Chicago, Ill.
Past-Chairmen—H. R. Alley, H. E. Weston, F. D. Long, J. L. Kubicka, W. R. Price, G. A. Zinkel, A. K. Roach, V. V. Vallandigham, E. C. Berg, and J. D. Johnson.
National Executive Committee Representative—F. D. Long, Container Corp. of America, Chicago, Ill.

Lake Erie

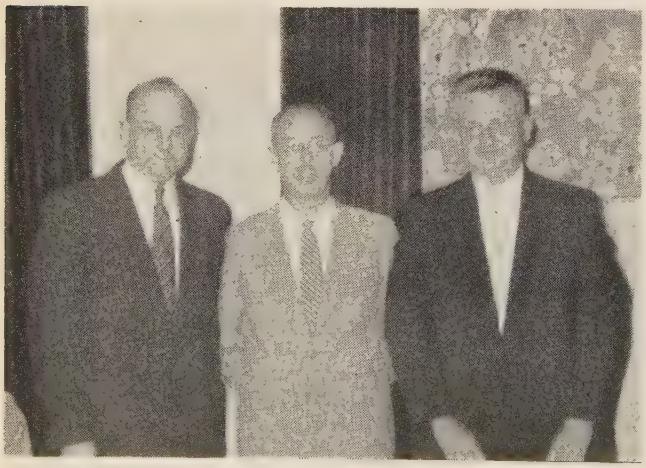
Chairman—Leo Gebo, Thomas Phillips Co., Akron, Ohio
First Vice-Chairman—Ted Welles, Moser Bag & Paper Co., Cleveland, Ohio
Second Vice-Chairman—C. A. Markee, The Ohio Boxboard Co., Rittman, Ohio
Treasurer—R. Mathews, Chase Bag Co., Chagrin Falls, Ohio
Secretary—Benno Beau, National Container Co., Jaite, Ohio
Financial Secretary—S. B. Gulliford, Gulliford Printing Co., Cleveland, Ohio
Executive Committee—R. L. Lewis, The Ohio Boxboard Co., Rittman, Ohio; Wm. (Bill) Schoenberg, Lord & Schoenberg, Cleveland, Ohio; Charles Daggett, Corn Products Sales Co., Cleveland, Ohio; John Preston, Federal Adhesives Corp., Cleveland, Ohio; John Richmond, The Ace Electrotype Co., Cleveland, Ohio; Marshall Veigel, National Aluminate Co., Cleveland, Ohio; Jim Krudrna, National Container Corp., Jaite, Ohio; and Dave Bechtold, Monsanto Chemical Co., Cleveland, Ohio
Past-Chairmen—L. K. Burnett, William Schoenberg, William Hasselo, R. L. Lewis, and Lloyd Shand
National Executive Committee Representative—D. J. Goodman, Sorg Paper Co., Middletown, Ohio

Southeastern

Chairman—C. N. Rogers, Sonoco Products Co., Hartsville, S. C.
Vice-Chairman—W. C. Chapman, Union Bag & Paper Corp., Savannah, Ga.
Secretary—C. L. Smith, National Container Corp., Jacksonville, Fla.
Treasurer—R. H. Homans, Brunswick Pulp & Paper Co., Brunswick, Ga.
Executive Committee—Officers and M. B. Pineo, Brunswick Pulp & Paper Co., Brunswick, Ga., and J. R. Lientz, Union Bag & Paper Corp., Savannah, Ga.
Past-Chairmen—G. C. Kimble and M. B. Pineo
National Executive Committee Representative—J. R. Lientz, Union Bag & Paper Corp., Savannah, Ga.

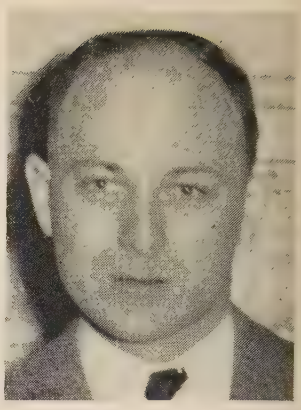
Chesapeake and Allegheny Paper Club

Chairman—J. H. Symes, National Container Corp., Big Island, Va.



R. J. Martin, Fraser Paper Ltd., Vice-Chairman; A. E. Jones, Oxford Paper Co., Chairman; H. E. Pratt, Pejepscot Paper Co., Secretary-Treasurer, Maine-New Hampshire Section

W. R. Willets, Titanium Pigment Corp.; Chairman, Empire State Section



D. B. Geffken, Oswego Falls Corp., Chairman; Central District, Empire State Section

Vice-Chairman—R. B. Hobbs, National Bureau of Standards, Washington, D. C.
Executive Committee—Officers and J. J. Priest, Halifax Paper Co., Roanoke Rapids, N. C.; William Jones, U. S. Department of Commerce, Washington, D. C.; and R. E. Traver, Camp Mfg. Co., Franklin, Va.

Papermakers and Associates of Southern California

Chairman—William Richards, Container Corp. of America, Los Angeles, Calif.
Co-Chairman—Ronald Boedeker, Container Corp. of America, Los Angeles, Calif.
Secretary-Treasurer—William Ingham, National Aniline Division, Los Angeles, Calif.
Past-Chairmen—H. L. Joachim, V. C. Farmer, C. G. Frampton, W. A. Kinney, F. H. Wheelock, R. S. Buckley, John Van Ounsem, W. G. Hartford, B. F. Brown, Jr., R. W. Stevens, Claude Sharp, W. C. Birdsey, J. T. Cooey, T. S. Markov, and A. R. Hooker, Jr.

Review of 1954–55 Section Meetings

The following review is a record of the meetings held by the Local Sections of TAPPI between September, 1954, and June, 1955. A report of the meetings held in 1953–54 appeared in the September, 1954, issue of *Tappi*.

Pacific

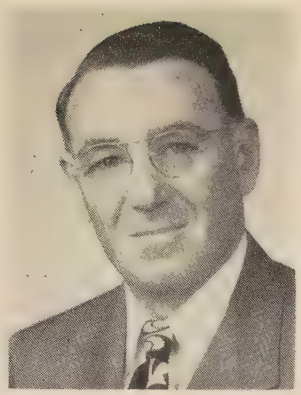
The Pacific Section was organized at Seattle, Wash., in June, 1929. The annual meeting is held in May.

Sept. 29, 1954 (Portland, Ore.): Annual Engineering Meeting, L. F. Mayback, Crown Zellerbach Corp., Camas, Wash., moderating. (1) "Kamyr Continuous Cooking," by Lennart Lundberg, A. H. Lundberg, Inc., Seattle, Wash. (2) "Recent Improvements in the West Linn Sulphite Mill," by R. Plankinton, Crown Zellerbach Corp., West Linn, Ore. (3) "Welding of Stationary Kraft Digesters," by George Conner, Willamette Iron & Steel Co., Portland, Ore. (4) "Industrial Engineering in a Crown Zellerbach Mill," by T. W. Leedham, Crown Zellerbach Corp., Camas, Wash. Dinner meeting held in the Multnomah Hotel, Portland, Ore. Dinner speaker, Herbert F. Rance, The Wiggins Teape Group Research Organization, Woodburn Green, Bucks, England.

Nov. 9, 1954 (Bellingham, Wash.): Annual Instrumentation Meeting, Norval Magnusson, Puget Sound Pulp & Timber Co., Bellingham, Wash., moderating. (1) "Sulphur Dioxide—Ammonia-Water System," by Dan Hayden, graduate student, University of Washington. (2) "Instrumentation of Ketchikan Pulp Co.," by Arthur Damman, Ketchikan Pulp Co., Ketchikan, Alaska. (3) Forum on "Control Valves for Handling Slush Pulp Stock." Dinner meeting at Leopold Hotel, Bellingham, Wash. Dinner speaker, Curtis Cortelyou, Ferndale Refinery, General Petroleum Corp., Ferndale, Wash.

Jan. 11, 1955 (Longview, Wash.): "What's New in Pulping," Paul S. Billington, Weyerhaeuser Timber Co., Longview, Wash., moderating. (1) "The Abatement of Kraft Mill Odors," by G. G. DeHaas and G. A. Hansen, Weyerhaeuser Timber Co. (2) "Chemistry of Sulphite Pulping," by Joseph L. McCarthy, University of Washington. (3) "Dome Corrosion in Lined

J. J. Forsythe, International Paper Co.; Chairman, Western District, Empire State Section



A. C. Dreshfield, Chicago Testing Laboratory; Chairman, Chicago Section

Digesters," by K. M. Shold, Crown Zellerbach Corp., Port Townsend, Wash. (4) "Applications of Radioisotopes in the Pulping Industry," by T. L. Kelley, Tracerlab, Inc., Berkeley, Calif. Dinner meeting held in Monticello Hotel, Longview, Wash. Dinner speaker, Kenneth Davis, professor of physics at Reed College, Portland, Ore.

March 4, 1955 (Everett, Wash.): Annual Shibley Award Meeting, Fred Weleber, Publishers' Paper Co., Oregon City, Ore., moderating. (1) "Rapid Method of Determination of the Alpha Cellulose Content of Pulp," by Kenneth A. E. Blackmore, Puget Sound Pulp & Timber Co., Bellingham, Wash. (2) "Paper Handling at the Trimmers," by J. V. Gould, Everett Pulp & Paper Co., Everett, Wash. (3) "A Simple Test as an Aid in the Control of Brown Stock Washing," by John Griffith, Crown Zellerbach Corp., Camas, Wash. (4) "Unique Structural Treatment Feature in New Filter Plant," by Don Wooden of Weyerhaeuser Timber Co., Everett, Wash. Dinner meeting held at Everett Elks Club. Dinner speaker, Dean Lloyd S. Woodburne, Dean of College of Arts and Sciences, University of Washington.

May 18–21, 1955 (Victoria, B. C.): Joint Meeting with Pacific Branch, Technical Section, CPPA, and Pacific Div., APPM Superintendents Association, John M. McEwen, Weyerhaeuser Timber Company, Everett, Wash., moderating. (1) "C. Z. Modernizes Paper Machine at Port Townsend," by R. R. Marriott, Crown Zellerbach Corp., Port Townsend, Wash. (2) "Structural Fiber, a Pulp With Its Own Problems," by Everett J. Reichman, Simpson Logging Co., Shelton, Wash. (3) "Continuous Chlorination of Bleach Liquor," by Harry S. Fisher and Richard E. Carlson, Pennsylvania Salt Manufacturing Co. of Washington, Tacoma, Wash. (4) "The Effect of Paper on Color Changes of Meat," by F. O. Whipple, Crown Zellerbach Corp., Camas, Wash.

Lake States

The Lake States Section was organized in Menasha, Wis., on Oct. 17, 1930. Meetings are usually held on the second Tuesday of the month in October, November, January, March, April, and May. The meetings are held in Appleton and other cities in Wisconsin.

Sept. 23, 1954 (Hotel Conway, Appleton, Wis.): with after dinner speaker, Borje Steenberg of the Swedish Forest Products Research Laboratory. "The Principles of Screening System of Design."

Nov. 9, 1954 (Menominee, Mich.): Mill tours were conducted through Badger Paper Mills, Peshtigo, Wis., Marinette Paper Co., Marinette, Wis., and Marathon Corp., Menominee, Mich. Dinner was served at Riverside Country Club in Menominee followed by fire control demonstrations by the Ansul Chemical Co. of Marinette.

Jan. 11, 1955 (Conway Hotel, Appleton, Wis.): Edgar Dickey, Institute of Paper Chemistry. "Chromatography for Control and Research in Pulp and Paper."

March 8, 1955 (Kaukauna, Wis.): Mill visit to the Thilmany Pulp and Paper Co. Dinner meeting at Kaukauna Elks Club with E. H. Jennings, President of Thilmany Pulp and Paper Co., the speaker.

April 12, 1955 (Appleton, Wis.): After dinner was served, the three best papers selected from those submitted for the C. J. West Award contest were presented, judged and the award winner chosen, the winner being Norman Beckman.

May 10, 1955 (Wisconsin Rapids, Wis.): Social gathering at the Bullseye Country Club. After dinner entertainment was furnished by the "Cardinals" Barbershop Quartet. Golf awards were presented and the results of the election of new Section officers were announced.

Kalamazoo Valley

The Kalamazoo Valley Section was organized May 4, 1931, at Kalamazoo, Mich. Its meetings are usually held at the Hotel Harris in Kalamazoo, Mich., on the first Thursday of each month.

Sept. 30, 1954: "Analytical Approach to Drying," by Alfred Nissan, University of Leeds, England.

Nov. 4, 1954: Symposium: "What Holds Paper Together?—The Basic Skeleton of Paper," by H. O. Ware, Hercules Powder Co., Kalamazoo, Mich.; "Hydration Bonding," by R. T. Elias, Western Michigan College, Kalamazoo, Mich.; and "Noncellulose Bonding Agents," by Frank Kaulakis, Clinton Foods, Inc., Clinton, Iowa.

Dec. 2, 1954: "New Testing Instruments and Methods." "Ultra-Viscoson," by Frank Kerney, Bendix Aviation Corp., Cincinnati, Ohio; "Development and Use of the L.T.F. Pick Tester," by Gordon Wheeler, Lithographic Technical Foundation, Chicago, Ill.; and "A New Instrument for Measurement of Porosity and Smoothness," by W. I. Wilt, Sheffield Corp., Dayton, Ohio.

Jan. 13, 1955: Joint meeting with Mich. Division, APPMSA, and "A Review and Preview of the Paper Industry," by D. C. Everest, Marathon Corp., Neenah, Wis.

Feb. 3, 1955: "The Technical Man Faces the Realities of Papermaking." "Stock Preparation," by S. I. Kukolich, Lee Paper Co., Vicksburg, Mich; "Bleaching," by A. H. Hupp, Watervliet Paper Co., Watervliet, Mich.; and" Trouble Shooting in the Mill," by W. F. Hathaway, The K.V.P. Co., Parchment, Mich.

Mar. 3, 1955: "Graphic Arts Meeting." Afternoon symposium: R. W. Wilkerson, Minerals and Chemicals Corp. of America, Metuchen, N. J.; Harry Hadley, Garden Board and Carton Co., Middletown, Ohio; John Langmaid, S. D. Warren Co., Cumberland Mills, Me.; D. L. Monaco, McGraw-Hill Publishing Co., N. Y.; A. Lewenstein, Appleton Coated Paper Co., Appleton, Wis. Evening meeting: "Order and Confusion in Color," by W. C. Granville, Container Corp. of America, Chicago, Ill.

April 7, 1955: "Engineering Meeting," conducted by Walter Mikelson, General Electric Co., Schenectady, N. Y.

May 5, 1955: "Research Today." Annual Senior Thesis Presentation. Seniors, Paper Technology Department, Western Michigan College, Kalamazoo, Mich. Also, "From Senior to Junior in Three Easy Lessons," by E. K. Stilbert, Dow Chemical Co., Midland, Mich.

June 2, 1955 (Gull Lake Country Club): Annual Fun Day. Election of 1955–56 officers.

New England

The New England Section was organized at Holyoke, Mass., on Dec. 9, 1932. The following meetings were held during the current year:

Oct. 8, 1954 (Berkshire Inn, Great Barrington, Mass.): "Let's Look and See," by A. F. Kirkpatrick, Research Div., American Cyanamid Co., Stamford, Conn.; "The Properties and Commercial Use of Papermakers Alum," by John Bainbridge, Monsanto Chemical Co., St. Louis, Mo.; mill visits to mills of Crane & Co., Dalton, Mass., and Byron Weston Co., Dalton, Mass.

Dec. 10, 1954 (Roger Smith Hotel, Holyoke, Mass.): "3D Microscopy," by Horace N. Lee, Lowell Technological Institute, Lowell, Mass.; "Some of the Newer Fibers and the Properties They Impart to Paper," by John N. McGovern, Parsons & Whittemore, Inc., New York, N. Y.; mill visits to mills of Crocker and Albion Divs., American Writing Paper Corp., Holyoke, Mass.

April 1, 1955 (Hotel Bond, Hartford, Conn.): Henry J. Perry, formerly Director, Waste Paper Utilization Council, New York, N. Y., and Robert Graham, President, Graham Corp., Boston, Mass., presented talks on several phases of the waste paper industry.

June 3–4, 1955 (Oceanside Hotel, Magnolia, Mass.): "The Development of a Quality Control Program for a Paper Mill," by C. P. Howell, Chemical Engineering Dept., University of Maine, Orono, Me. and "Microscopy—Stop, Listen and then Look," by Horace N. Lee, Lowell Technological Institute, Lowell, Mass. Mill visits were conducted at Haverhill, Mass., mill of the Robert Gair Co., Inc. and the Paper Engineering Building of Lowell Technological Institute, Lowell, Mass.

Ohio

The Ohio Section was organized on Nov. 30, 1934, at Middletown, Ohio.

Sept. 16, 1954: "Recent Investigation at the Institute of Paper Manufacturing at Darmstadt," by W. H. Brecht, Director of the Institute of Paper Manufacturing, Darmstadt, Germany.

Oct. 7, 1954: "Atomic Energy Applied to Industry," by Carl Ludeke, University of Cincinnati, Cincinnati, Ohio.

Nov. 16, 1954: "Treatment of Industrial Wastes," by H. H. Black and Gerald McDermott, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio. Tours were held during the afternoon through the Little Miami Sewage Treatment Plant and the Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio.

Dec. 9, 1954: "Human Engineering in the Pulp and Paper Industry," by George Pringle, The Mead Corp., Chillicothe, Ohio.

Jan. 11, 1955: "Stock Preparation," by Alfred H. Nadelman, Western Michigan College, Kalamazoo, Mich.

Feb. 10, 1955: "Printing and Paper," by M. C. Rogers, R. R. Donnelly & Sons, Chicago, Ill.

March 8, 1955: "The Potentialities of Instrumental Measurement of Appearance Properties of Materials," by Richard S. Hunter, Hunter Associates Laboratory, Falls Church, Va.

April 14, 1955: A panel discussion on "Pigments for Use in the Paper Industry," by R. W. Hagemeyer, Wyandotte Chemical Corp., Wyandotte, Mich.; Nathan Millman, Huber Corp., Huber, Ga.; Louis B. Taylor, Columbia-Southern Chemical Corp., Pittsburgh, Pa.; and William R. Willets, Titanium Pigment Corp., New York, N. Y.

May 12, 1955: Annual meeting featuring a Ladies' night. Entertainment and election of officers.

Empire State

The Empire State Section began holding meetings in 1935, in Syracuse, N. Y., and received its charter on April 2, 1938. In 1943, the Section was reorganized on a regional basis with meetings being held in four districts (Central, Eastern, Northern, and Western) of New York State. In 1948, the Metropolitan District was added.

May 6, 1955 (University Club, Syracuse, N. Y.): Fifth Annual dinner for the Seniors at the College of Forestry, State University of New York. B. P. Burtt, Chemistry Department, Syracuse University, was the speaker.

June 9–11, 1955 (Whiteface Inn, Lake Placid, N. Y.), Annual meeting: (1) "The Seaway—Its Economic Significance," by G. O. Von Frank, Associate Economist, New York State Department of Commerce. (2) "Availability of Words in New York," by James Davis, State University of New York, College of Forestry. (3) "Semichemical Pulping," by R. M. Husband, State University of New York, College of Forestry. (4) "Machine Coating of Paper Board—The Coating Equation," by H. C. Fisher, Gardner Board & Carton Co., Lockland, Ohio. (5) "Printing of Board or Paper by the Lithographic Process," by Ray Salvoy, Stecher-Traung, Inc., Rochester, N. Y. (6) "Coating, Laminating, and Pasting for Converted Paper Products," by W. E. Anderson, Riegel Paper Corp., Milford, N. J. (7) Empire State Award papers: (a) "Centricleaning of Sulphite Pulp," by Donald Anderson, International Paper Co., Palmer, N. Y. (b) "Experiences with Molded Fiber Sizing," by Norman Rauscher, Diamond Match Co., Plattsburg, N. Y. (c) "The Pulping of Hardwoods," by M. A. Aung, St. Regis Paper Co., Deferiet, N. Y. (8) "The Ninth Element," a film presented by Titanium Pigment Corp., New York, N. Y.

CENTRAL DISTRICT (University Club, Syracuse, N. Y., first Friday of the month)

Oct. 1, 1954: "The Development of Strength on the Paper Machine," by Wilfred Gallay, The E. B. Eddy Co., Hull, P. Q.

Nov. 5, 1954: "Quality Control," by J. E. Ray, Scott Paper Co., Chester, Pa.

Dec. 3, 1954: "Deinking at Newton Falls Paper Mill," by J. W. Morrow and J. D. Lohnas, Newton Falls Paper Mill, Inc., Newton Falls, N. Y.

Jan. 7, 1955: "Waste Paper Utilization," by H. J. Perry, Waste Paper Utilization Council, New York, N. Y.

Feb. 4, 1955: "Screening," by H. F. Schenk, Magnus Metal Corp., Fitchburg, Mass.

March 4, 1955: "New Developments in Paper Machine Design," by C. H. Swartz, Beloit Iron Works, Beloit, Wis.

April 2, 1955: "Interesting Developments in Titanium Research," by H. C. Brill, E. I. du Pont de Nemours & Co., Newport, Del.

May 6, 1955: "A Lecture in Chemistry," by B. P. Burtt, Syracuse University, Syracuse, N. Y. (Fifth Annual Senior Dinner sponsored by Empire State Section.)

June 3, 1955: Ladies night. Annual meeting.

EASTERN DISTRICT (Queensbury Hotel, Glens Falls, N. Y., third Thursday of the month)

Oct. 21, 1954: Plant visit to Albany Felt Co., Albany, N. Y. Discussion of quality control and felt design led by James Smith, Albany Felt Co., Albany, N. Y.

Nov. 18, 1954: (1) "Some Recent Developments in Beater Addition of Phenol Aldehyde Resins," by A. E. Moyer, Snyder Chemical Co., Bethel, Conn. (2) "Addition of Latices to Pulp Supply Systems," by R. L. Steller, B. F. Goodrich Co., Cleveland, Ohio. (3) "Neoprene and Other Additions," by Jack Hickman, E. I. du Pont de Nemours & Co., Wilmington, Del.

Dec. 16, 1954: (1) "Flat Diaphragm Screens," by A. A. Lowe, Sandy Hill Iron & Brass Works. (2) "Screens and Screening Problems," by H. F. Schenk, Magnus Metal Co., Fitchburg, Mass.

Jan. 20, 1955: "Suggestions Systems an Aid to the Technical Division," by R. C. Reed, General Electric Co., Schenectady, N. Y.

Feb. 17, 1955: "The Use of Filming Amines in the Paper Industry," by J. G. Weidman, W. H. & L. D. Betz Co., Philadelphia, Pa.

March 17, 1955: "Pulping of Bagasse Fiber and Its Possibilities as a Substitute for Ground Wood and Other Fibers," by Dr. Hutchison, Parsons & Whittemore, Inc., New York, N. Y.

April 21, 1955: (1) "Slime Control," by J. R. Sanborn, National Aluminate Co., Chicago, Ill. (2) "Centri-Cleaning of Sulphite Pulp," by Donald Anderson, International Paper Co., Palmer, N. Y. (3) "Experiences with Molded Fiber Sizing," by Horman Rauscher, Diamond Match Co., Plattsburg, N. Y.

May 21, 1955: Ladies Night. Annual Meeting.

METROPOLITAN DISTRICT (Fraunces Tavern, New York, N. Y., second Tuesday of the month)

Sept. 14, 1954: "Practical Examples in the Development of Paper Coatings," by W. L. Hardy, Foster D. Snell, Inc., New York, N. Y.

Oct. 19, 1954: "General Principles of Packaging," by T. J. Gross, Union Bag & Paper Corp., New York, N. Y.

Nov. 9, 1954: "The Practical Application of Statistical Quality Control in a Board Mill," by Joseph Theriault, Robert Gair Co., Uncasville, Conn.

Dec. 4, 1954: "Let's Look and See," by A. F. Kirkpatrick, American Cyanamid Co., Stamford, Conn.

Jan. 11, 1955: "The Papermaking Properties of Various Wood Pulps," by Gerald Haywood, West Virginia Pulp & Paper Co., New York, N. Y.

March 8, 1955: "Gravure Inks," by G. E. Jacques, Commercial Ink & Lacquer Co., Inc., Fair Lawn, N. J.

April 12, 1955: "Beating as Applied to Paper Mill Stock Preparation," by T. Agronin, Black-Clawson Co., New York, N. Y.

May 10, 1955: Ladies night. Presentation of film, "The Ninth Element," by Titanium Pigment Corp.

NORTHERN DISTRICT (Hotel Woodruff, Watertown, N. Y., second Thursday of the month)

Oct. 14, 1954: "Local Yokel's Nite." Short talks by mill men on new developments in their mills.

Nov. 11, 1954: Human Relations and the Industrial Executive," by E. J. Mickel, Dale Carnegie Institute, New York, N. Y.

Dec. 9, 1954: "The Use of Instruments at Newton Falls," by Alfred Wagner, Newton Falls Paper Mills, Inc., Newton Falls, N. Y.

Jan. 13, 1955: "What the State College of Forestry Has to Offer in Industry and to High School Students and Opportunities in Paper Manufacture," by F. G. O'Neil, State University of New York, College of Forestry, Syracuse, N. Y.

Feb. 10, 1955: "Inter-Relations Among Properties of Paper," by Dr. Wilfred Gallay, E. B. Eddy Co., Hull, P. Q.

March 10, 1955: "Basic Weight and Caliper Control"—panel discussion, J. W. Morrow, Newton Falls Paper Mills Inc., Newton Falls, N. Y.—Moderator. Representatives from Fisher and Porter; Bird Machine Co., Electric Eye Equipment Co., and Industrial Nucleonics.

April 14, 1955: (1) "The Pulping of Hardwoods," by M. A. Aung, St. Regis Paper Co., Deferiet, N. Y. (2) "Bubbles," by J. B. Sisson, St. Regis Paper Co., Deferiet, N. Y.

May 19, 1955: Ladies night. Annual meeting.

WESTERN DISTRICT (Prospect House, Niagara Falls, N. Y., first Wednesday of the month)

Nov. 3, 1954: Panel discussion on Instrumentation. "Paper in the Making," film by International Paper Co., New York, N. Y.

Dec. 1, 1954: "The Services of TAPPI to Pulp and Paper

Mill Management," by R. G. Macdonald, TAPPI, New York, N. Y.

Feb. 2, 1955: Plant Visit—J. W. Clement Co., Buffalo, N. Y.

March 8, 1955: "Managers of Men," by J. A. Turney, Provincial Engineering Co., Toronto, Ont. (joint meeting with CPPA at St. Catherines, Ont.).

April 6, 1955: "New Material for the Paper Industry," by following panel: (1) F. A. Strovink American Cyanamid Co., Boston, Mass. (2) R. Harter, R. T. Vanderbilt Co., South Norwalk, Conn. (3) S. F. M. MacClaren, Penick & Ford Ltd., Buffalo, N. Y. (4) M. L. Cushing, Stein Hall & Co., New York, N. Y.

May 5, 1955: Ladies night. Annual meeting.

Maine-New Hampshire

The Main-New Hampshire Section was organized at Orono, Me., on Oct. 25, 1940, and received its charter at Bangor, Me., on Oct. 26, 1945.

Sept. 10–11, 1954 (Madawaska Inn, Madawaska, Me.): "An Analytical Approach to the Problem of Drying Their Fibrous Sheets on Multicylinder Machines," by A. H. Nissen, The University, Leeds, England. Visit to the mills of the Fraser Co., Edmunston, N. B., and Madawaska, Me. Woods trip—Pulpwood Cutting and Fire Fighting Demonstration.

June 24–25, 1955 (Eastern Slope Inn, North Conway, N. H.): "Operating Problems on High Speed Tissue and Towel Machines," by C. M. Howell, University of Maine, Orono, Me. "Some Important Items in Building a Paper Machine Not Included in Contract Specifications," by S. M. Bratton, Pusey & Jones Corp., Wilmington, Del., "Difficulties in Operating a Paper Machine at 1800 Ft. per Min.," by A. E. Levensailor (read by J. A. MacLean, Great Northern Paper Co., Millinocket, Me., "Adjustments and Start-up Problems of a Suction Pick-up on a High Speed News Machine," by Edward Beachler, Beloit Iron Works, Beloit, Wis.; visit to the mill of the Brown Co., Berlin, N. H.

Chicago

The Chicago Section was organized as the Chicago Professional Paper Group in Chicago, Ill., in October, 1943. In 1946 the group became the Chicago Section. All meetings are held in the rooms of the Chicago Bar Association on the second Monday of the month beginning September through May.

Sept. 20, 1954: "Folding Cartons," by Leonard Scheck, Container Corp. of America, Chicago, Ill.

Oct. 11, 1954: "Personnel Developments," by Richard L. Warner, Mead Corp., Chillicothe, Ohio.

Nov. 15, 1954: "Greaseproofness in the Packaging Industry," by (panel speakers) J. C. Wood, Kalamazoo Vegetable Parchment, Kalamazoo, Mich., R. W. Reid, Rhinelander Paper Co., Rhinelander, Wis., C. P. Kulesza, Reynolds Metals, Richmond, Va., Warren Price, Central Waxed Paper Co., Chicago, Ill.

Jan. 17, 1955: "Developing New Markets for Paper—Progress Report on Melo-Strength Resin Treated Papers," by (panel speakers) A. M. Asherman, American Cyanamid Co., E. C. VanWart, American Cyanamid Co., New York, N. Y., and G. E. Fromm, American Cyanamid Co., Chicago, Ill.

Feb. 14, 1955: Valentine's Day Party at Chicago Bar Association.

March 14, 1955: "Easy-Open Devices for Corrugated Containers and Other Packages," by (panel speakers) Lee Paul, Minnesota Mining and Mfg. Co., St. Paul, Minn., and Alden Tyer, Chicago Printed String Co., Chicago, Ill.

April 11, 1955: "Hi-Speed Photomicrograph Moving Picture of Inks," by Frank Dick, International Printing Ink, and Joseph Steinbruner, International Printing Ink, Chicago, Ill.

May 9, 1955: "Adhesives and Their Evaluation," by (panel speakers) Wm. D. Hall, Folding Paper Box Assn. of America, Chicago, Ill., D. G. Williamson, Williamson Adhesive Co., Skokie, Ill., and K. M. Fraze, American Can Co., Maywood, Ill.

Lake Erie

The Lake Erie Papermakers and Convertors Association was organized at the Hickory Grille, Cleveland, Ohio, on Oct. 7, 1949. Meetings are held on the third Friday of each month at the Carter Hotel, Cleveland, Ohio. This organization received its charter as the Lake Erie Section on May 18, 1951.

Sept. 10, 1954: "Industrial Engineering Offers New Production Aids to the Paper Industry," by Lewis W. Helmick, Management Consultant of Alliance, Ohio.

Oct. 8, 1954: "Board Versus Light Weight Kraft As It Affects Material Suppliers." This was a panel type program, the speakers were Ted Welles, Moser Bag and Paper Co., Cleveland, Ohio; C. P. Spring, National Container Corp.; Douglas Adams, Canton Corrugated Co., Canton, Ohio; Charles Markee, The Ohio Boxboard Co., Rittman, Ohio; Al Daniels, Chase Bag Co., Chagrin Falls, Ohio.

Nov. 12, 1954: "Resins for the Paper Industry, New Horizons," speaker, Donald Black, Development and Technical Service Dept., Plastics Division of Monsanto Chemical Co.

Dec. 11, 1954: Christmas Party.

Jan. 14, 1955: "Material Handling," speaker Henry Bernbaum, Industrial Engineer of the American Greeting Publishers Co. Cleveland, Ohio.

Feb. 11, 1955: "Measurement and Control in the Graphic Arts," speakers, Lars Sjodol of the Gardner Board and Carton Co., Middletown, Ohio, and R. J. Mc Eachen, The Union Printing Inks Co., Columbus, Ohio.

April 15, 1955: "Control of Printing Inks and Testing Techniques," speaker, J. F. Steinbruner of Interchemical Corp., Chicago Division.

May 24, 1955: Annual meeting and election of officers. "Problems in Making Machine Coated Paperboard," speaker, Melvin M. Johnson, Container Corp. of America, Wabash, Ind. "Factors in Printing of Mineral Coated Paperboard," speaker, Harry C. Fisher of Gardner Board and Carton Co., Cincinnati, Ohio.

Southeastern

The Southeastern Section of TAPPI was organized in Macon, Ga., in the summer of 1951 as the Southeastern Pulp and Paper Society. The charter was granted to the Section and presented by R. G. Macdonald, Secretary of TAPPI, at the Brunswick, Ga., meeting on Sept. 19, 1952. Meetings are held five times during the program year from September to May. Places and dates of meetings in South Carolina, Georgia, and Florida, are designated by the Executive committee.

Oct. 1–2, 1954 (Valdosta Country Club, Valdosta, Ga.): (1) "Selection of Valdosta as a Mill Site," by W. T. Webster, Vice-President and General Manager, National Container Corp., Jacksonville, Fla. (2) "Basket Cooks in the Mill Digesters," by W. M. Blume, West Virginia Pulp and Paper Co., Charleston, S. C. (3) "Union Bag's New Triple Automatic Extraction Turbine," by C. C. Bush, Union Bag and Paper Corp., Savannah, Ga., and G. D. Farrar, Turbine Specialist, General Electric Co., Atlantic, Ga., presented by Mr. Bush. (4) "Principles of Screening and Screening System Design," by B. K. Steenberg, Research Director, Swedish Forest Products Research Laboratory, Stockholm, Sweden. Tours of National Container Corp. mill, Clyattville, Ga.

Nov. 12–13, 1954 (King & Prince Hotel, St. Simons Island, Ga.): (1) "Sulphate Black Liquor Oxidation." by T. T. Collins, National Container Corp., Jacksonville, Fla. (2) "Wire and Wet Felt Performance Records," by J. M. Mallory, Union Bag and Paper Corp., Savannah, Ga. (3) "Some Problems Relating to Digester Yields," by G. M. Dickinson, Sonoco Products Co., Hartsville, S. C. (4) "A Few of the Unsolved Chemical Problems of the Pulp Maker," by Harry F. Lewis, Institute of Paper Chemistry, Appleton, Wis. Mill tours of Brunswick Pulp and Paper Co. plant, Brunswick, Ga.

Jan. 14–15, 1955 (Francis Marion Hotel, Charleston, S. C.) Evening Session: (1) "Teamwork in Forest Utilization," by L. A. Whittle, Brunswick Pulp & Paper Co. (2) "Outside Storage of Wood," by H. H. Flickinger, International Paper Co. (3) "St. Regis and the Purchased Chip Program," by Stephen P. Koptain, St. Regis Paper Co. (4) "Pulping Chips from Saw Mill Waste," by Milton R. Roberts, St. Regis Paper Co. Morning Session: (15th) (1) "Conservation Practices in Connection with Wood Procurement," by B. E. Allen, Union Bag & Paper Corp. (2) "Industry's Part in Forest Genetics," by Peter T. Lonnan, Jr., West Virginia Pulp & Paper Co.'s Experimental Forest. (3) "Greater Pulp Yield per Acre per Year," by Harold L. Mitchell, Forest Products Laboratory. (4) "Forestry Research by Union Bag," by Barry Malac, Union Bag and Paper Corp.

March 18–19, 1955 (George Washington Hotel, Jacksonville, Fla.): (1) "Reduction of B.O.D. Load from the Mill of Southern Paperboard by Balancing and Improving the Recovery System," prepared by David Wetherhorn and presented by J. H. Smith, both of Robert Gair Co., Savannah, Ga. (2) "Two Slice Headboxes for Fourdrinier Machines," by W. B. Roberson of Hudson Pulp and Paper Co., Palatka, Fla. (3) "Rate of Gain or Loss in Kraft Paper and Board," by John S. Moore, Union Bag and

At the Brown Co. during the Spring meeting of the Maine-New Hampshire Section

Paper Corp., Savannah, Ga. (4) "Paper Research at the National Bureau of Standards," by Robert B. Hobbs, Chief, Paper Section, National Bureau of Standards, Washington, D. C. Mill tours of Hudson Pulp and Paper Co., Palatka, Fla.

May 13–14, 1955 (Hotel DeSoto, Savannah, Ga.): (1) "The Effect of 'Hurricane Hazel' on Process Water Quality at Riegel Carolina," by Noel R. Phillips, C. S. Ruark, and G. J. Simpson, of Riegel Carolina Corp. The paper was presented by Mr. Phillips. (2) "The Design, Construction, and First Year's Operation of a One Million Gallon Per Day Bio-Oxidation Pilot Plant at Sonoco Products Company," by B. M. Reaves of Sonoco Products Co. (3) "Acidizing Water Wells for Flow Improvement," by Joseph Velardi of Rayonier, Inc., Fernandina Beach, Fla. (4) "Some Management Problems in the Planning and Starting of a New Mill," by K. O. Elderkin, Bowaters Southern Paper Corp. Election of officers. Guided tour of Union Bag and Paper Corp. mill.

Southeastern Section Roster of Officers, 1954–55

Chairman, M. B. Pineo; *Vice-Chairman*, C. N. Rogers; *Secretary*, Roy Homans, Corresponding, and C. L. Smith, Recording; *Treasurer*, G. E. Scofield; *Past-Chairman*, G. C. Kimble; *Local Arrangements*, W. M. Ackerman; *Executive Committee*, M. B. Pineo, C. N. Rogers, G. C. Kimble, J. R. Lientz, G. E. Scofield, C. L. Smith, Roy Homans, W. M. Ackerman.

Chesapeake and Allegheny Pulp and Paper Club

The Chesapeake and Allegheny Pulp and Paper Club was organized at Richmond, Va., in September, 1954. Meetings are held bimonthly from September to May in Richmond, Va., Raleigh, N. C., Washington, D. C., or other cities in the club's area.

Watching the wet end operations during the Maine-New Hampshire Section visit to the Brown Co.

Sept. 17, 1954 (Hotel Jefferson, Richmond, Va.): "Organization and Functions of a Regional Paper Club," by C. E. Libby, North Carolina State College; "TAPPI and Its Local Sections," by R. G. Macdonald, Secretary, TAPPI.

Nov. 19, 1954 (Hotel Jefferson, Richmond, Va.): Guided tour, Seaboard Division, Manchester Board and Paper Co. "W. Va. Pulp & Paper Co.'s Waste Treatment System at Covington," by James Kniskern, West Virginia Pulp and Paper Co., Luke, Mo.

Jan. 28, 1955 (College Union, North Carolina State College, Raleigh, N. C.): "Chlorine Dioxide Bleaching," by A. L. Wiley, Riegel Carolina Corp., Acme, N. C., and R. L. Wheless, Camp Manufacturing Co., Franklin, Va.

March 25, 1955 (National Bureau of Standards, Washington, D. C.): Symposium on Preservation of Records; Chairman, George Smith, Library of Congress. "Preservation Practices at National Archives," by James Gear, National Archives. "Experiences in Testing Paper and Other Writing Materials for Use in State and County Public Offices," by Leon de Valinger, Jr., State Archivist of Delaware. "Degradation of Cellulose by Ultraviolet Light," by J. H. Flynn, National Bureau of Standards. "Trends in the Types of Paper for Long Life Records," by Lewis S. Reid, Metropolitan Life Insurance Co. Demonstration run of glass-fiber paper by M. J. O'Leary and staff, National Bureau of Standards Experimental Paper Mill. Dinner at Brook Farm, Chevy Chase, Md. "Modern Printing Inks," by W. T. Diefenbach, Bureau of Engraving and Printing

Two of the group watching the converting operations at the Brown Co.

May 20, 1955 (Princess Anne Hotel, Fredericksburg, Va.): "What You Can Learn About the Fine Structure of Cellulose by Acid Degradation," by O. A. Battista, American Viscose Co., Marcus Hook, Pa.

Papermakers and Associates of Southern California

The Papermakers and Associates of Southern California was organized in Los Angeles, Calif., on May 15, 1941. Meetings are held on the third Thursday of alternate months at Los Angeles.

Sept. 16, 1954 (Swally's Key Club): "Problems Analysis," by V. V. Vallandigham, Potlatch Forest, Inc., Lewiston, Idaho.

Nov. 18, 1954 (Flintkote Co. Cafeteria, Los Angeles, Calif.): Plant tour of Container Corp. of America.

Jan. 20, 1955 (Swally's Key Club): "New Instruments for Paper Mills." Discussion led by Walter Mikelson, General Electric Co., Schenectady, N. Y.

March 17, 1955 (The Chateau, Lynwood, Calif.): "Paperboard for Converters," Panel R. Le Narz, Robert Gair Co., W. Richards, Container Corp. of America, John Van Ounsem, Pioneer-Flintkote Co., Ted Markow, Fibreboard Products, Inc., Herbert Bridgen, Fibreboard Products, Inc., Chas. Colman, Pioneer-Flintkote Co., R. Brown, Container Corp. of America, and Clarence Yoder, Robert Gair Co.

April 16, 1955 (Club Del Mar, Santa Monica, Calif.): Wino-Dino Dinner Dance.

May 19, 1955 (The Chateau, Lynwood, Calif.): "What Can the Industrial Research Center Do for Papermakers in Southern California?" by Frank Miller, Director of Commerce and In-

A group of the dry end of "Mister Nibroc" during the visit to the Brown Co.

dustrial Relations, University of Southern California, Los Angeles. "A Check List for Effective Supervision," by Vernon D. Keeler, Consultant, Los Angeles.

July 21, 1955 (The Chateau, Lynwood, Calif.): "Raw Materials Handling Equipment." by Williams Van Voorhis, Fibreboard Products, Inc., Los Angeles; "Jordans," by Lester P. White, Container Corp. of America, Los Angeles; "Hydrapulpers," by William Tracey, Pioneer-Flintkote Co., Los Angeles; and "Suction Rolls," by James Thornton, Downingtown Mfg. Co., Downingtown, Pa.

Maine-New Hampshire

One of the most interesting phases of the Spring Meeting of Maine-New Hampshire section at Eastern Slope Inn (June 24–25) was a conducted tour by groups through the Cascade mill of the Brown Co. in Berlin, N. H.

During the trip, the delegates were permitted ample time to inspect and discuss the latest developments in paper machine design and manufacturing techniques used in modern paper towel production. Of special interest in the machine room was the paper machine designated as "Mister Nibroc." The delegates also visited the converting department where considerable interest was shown in the novel packing and case loading distribution system.

E. N. Poor

TAPPI Overseas Discussion Group

The following papers were presented at the meeting of the TAPPI Overseas Discussion Group which was held in Paris, France, May 20–21, 1955.

Hydrotropic Pulping of a Tropical Wood

Traynard A. Robert

The phenomenon of hydrotropy was discovered by Neuberg in 1916. Very concentrated solutions of a number of salts can dissolve substances which are insoluble in water.

Such are near-saturated solutions of benzoic, salicylic, benzene-sulphonic, xylene-sulphonic, cymene-sulphonic, and naphthalene-sulphonic acid salts. The substances dissolved by hydrotropic solutions are many: alcohols, hydrocarbons, aldehydes, amines, etc.

Hydrotropy ceases when the salt solution becomes insufficiently concentrated: the dissolved substance is then "salted out."

This solubility is probably due to the "third solvent." The salt, e.g., sodium benzoate, is the true solvent; the water is the non-solvent, a small quantity of which does not impair the solubility but a larger quantity of which destroys it.

The application of hydrotropy to delignification has been undertaken by Lau, Pelipetz, and McKee; the latter has undertaken a considerable work on pilot plant scale. In France, Eymery has carried out a thorough investigation of the mechanism of hydrotropic delignification, and studied the lignins thus obtained. The following is taken from his work.

The wood is treated in a digester with a concentrated solution of hydrotropic salt, at 150°C, for about 12 hr.

The hydrotropic salts used are alkaline salts of benzoic, xylene-sulphonic, and cymene-sulphonic acid salts. Salicylic, benzene-sulphonic, and toluene-sulphonic acid salts are also used. Ammonium and calcium salts also have a hydrotropic effect, but their efficiency is less.

The major portion of the lignin is dissolved. The liquor may be reused six or seven times for the treatment of fresh chips, until it is saturated with lignin. The lignin may then be recovered by diluting the solution. The precipitate is filtered off, and the filtrate is concentrated in a triple-effect evaporator and brought back to the adequate concentration for pulping. The hydrotropic salt is thus recirculated. This step is essential for the salt is costly compared with the usual disincrustants. The hydrotropic salt advised by McKee is sodium xylene-sulphonate, which has a very strong hydrotropic action at 30 grams per 100 ml. water (23%), a small quantity compared with other salts. Besides, such a solution, diluted three times, loses its hydrotropic properties, whereas sodium cymene-sulphonate has to be diluted much more (to 2%), hence extra charges for concentrating the liquor after precipitating the lignin.

A difficulty of the new process is the washing of the pulp. This must be done so as to avoid precipitating the lignin on the fibers. The pulp may be washed with a fresh solution of hydrotropic solvent. For water-resistant wrapping papers and boards, washing is much less exhaustive, and the hydrotropic lignin solution is used as a kind of size. The sizing occurs when the paper is dried and calendered, the hydrotropic lignin melting and acting as a thermoplastic resin. The paper thus obtained is of course very dark; however, it may have a very good finish. The main feature in this case is the high yield (75 to 85%).

If the lignin is not reincorporated into the pulp as above, the washed pulp may be bleached by the conventional procedures. The yield of bleached pulp is higher than any obtained with known procedures.

In the case of poplar, for instance, the yield is about 53% (46% by the usual procedures).

The quality of cellulose is better: the alpha-cellulose percentage is about 89 to 93%, the copper number 1.9 to 2.3, the ash content 0.01%. Therefore, the pulp would be quite desirable for rayon manufacture.

Eymery has shown that the hydrotropic delignification process occurs in a neutral medium, near pH 7. In these conditions no acid splitting of cellulose chains is to be feared. The hydrotropic reactive merely hydrolyzes the bond between the lignin and the carbohydrates, then dissolves the free lignin which therefore cannot polymerize.

We have attempted a complete study of the pulping of a tropical wood and chosen the *Ilex Sebertii*, of the *Aquifoliaceous* family from New Caledonia.

This hardwood has a texture which resembles that of a European wood; this is seen in its main characteristics.

Moisture content of chips	11%
Moisture content of wood meal (through 40-mesh screen)	8.56%
Ash content (wet wood)	0.87%
Ash content (dry wood)	0.98%
Alcohol-benzene extract (on dry wood) (TAPPI standard)	7.35%
Lignin (sulphuric acid procedure)	17.3%
Cellulose (Kürchner)	49.7%

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Table I

	Unbleached pulps			Bleached pulps					
				1st run ClO_2Na		2nd run H_2O_2		3rd run ClONa	
	Raw 10°S.-R.	Beaten 28°S.-R.	Beaten 53°S.-R.	Raw	52°S.-R.	Raw	40°S.-R.	Raw	74°S.-R.
Average basis weight, g./sq. m.	71.1	60.5	66.8	64.8	65.1	62.7	60.1	66	66.5
Breaking length, m.	2080	8550	8300	1520	9230	1230	8900	1280	9750
Burst (Ashcroft)	12.1	52.5	56	9.85	66.5	5.8	51.5	5.5	64
Tear (AFNOR)	76	56	47.3	54.2	62.8	61	37	48.7	33.9
Fold (Schopper) (tension 1 kg.)	6	521	760	6	220	4	245	0	632
Porosity (AFNOR) (average of both sides)	121	0.033	0.05	∞	0.03	∞	0.033	∞	0.035
Bulk	2.18	1.49	1.29	1.98	1.39	2.49	1.41	1.85	1.05
Moisture, %	9.17	9.1	9.07	9	9	6.3	8	8.7	8.5

The pulping was carried out according to the technique followed by Eymery. Sodium benzoate was preferred to other hydrotropic solvents for supply reasons, but it is probably not the best solvent.

Pulping Features

Pulping agent: 40% sodium benzoate.
Liquor/wood ratio = 7 (2.8 kg. of sodium benzoate per kg. of dry wood).
Pulping in rotary digester, indirect heating.
Time to maximum pressure: 2.5 hr.
Relief at 120°C.
8 hr. at 150°C.
End of pulping with "dead steam."
Pulp washing: with 40% sodium benzoate, then hot water.
Defibering in Lamort disintegrator.
Fractionating on Weverk classifier (20/10 slits).
Unbleached pulp yield: 43%.

The unbleached pulp gives several interesting indications.

The permanganate number and sulphuric lignin content are very low, which makes bleaching very easy. The most conspicuous feature is the ease of beating.

Unbleached Pulp Characteristics

Schopper-Riegler number	10
TAPPI permanganate number	15.6
Lignin (sulphuric acid procedure)	5.7%
Holocellulose (sodium chlorite procedure)	94.6%
Pentonsans (as furfural)	8.95%

Lampen mill beating
8,000 rev.: 28° Schopper-Riegler
16,000 rev.: 53° Schopper-Riegler
Raw and beaten unbleached pulp handsheets made on a British sheet machine.

A brief micrographic survey showed that the fibers were similar to firwood tracheids.

Three-stage bleaching has been carried out by three different procedures. The first two stages are the same for all pulps (double hypochlorite bleaching followed by washing).

The third stage was a treatment with hypochlorite, chlorite, or hydrogen peroxide.

	1st run	2nd run	3rd run
1st stage: t = 40°C; pH = 9.6	ClONa (4% Cl)	ClONa (4% Cl)	ClONa (4% Cl)
2nd stage: t = 40°C; pH = 9.6	ClONa (2% Cl)	ClONa (2% Cl)	ClONa (2% Cl)
3rd stage	ClO_2Na (2.5% Cl)	H_2O_2 (3% Cl)	ClONa (2% Cl)
	t = 75°C. pH = 4.6	t = 65°C. pH = 10.5	t = 40°C. pH = 9.6
Total chlorine consumed	7.8%	8.1%	7.55%

Pulp consistency 5%.

Brightness obtained: with hypochlorite: 74° (60° after beating—32,000 rev., 74°S.-R.); with chlorite: 74° (69° after beating—16,000 rev. 52°S.-R.); with peroxide: 72.5° (58° after beating—16,000 rev., 58°S.-R.).

The best results are therefore given by chlorite, and the worst, surprisingly, by peroxide.

These results are partly borne out by chemical analysis (copper number, iodine number) which shows greater degradation of peroxide-bleached pulp.

Characteristics of Bleached Pulps

	Bleaching procedure		
	No. 1	No. 2	No. 3
Iodine number	0.4	0.53	0.42
Copper number (Braidy)	0.51	0.91	0.66
Alpha-cellulose	86.3%	84.6%	79.0%
Mahood number	21.01	24.7	22.5
Pentosans	5.8%	5.65%	7.81%
Average D.P.	1450	1260	1100

The degradation produced by peroxide also affects the physical characteristics.

Table I shows that the quality of the papers is good: breaking length 9000 to 10,000 m.; Ashcroft burst 50 to 66, slightly low compared to birch.

The tearing strength is about the same as for a European hardwood.

Finally, one of the features of sodium benzoate cooks is that they give easy-beating pulps (even with straw).

Presented at the meeting of the TAPPI Overseas Discussion Group held in Paris, France, May 20–21, 1955.

The Use of *Ailantus Glandulosa* as Pulpwood

K. J. Adamik

To FORESTALL the threatening and already existing scarcity of pulpwood, there has been a trend toward the cultivation and planting of fast-growing species. The first of these were, in Europe, some species of poplar and gum.

POPLAR

Poplars give exceptionally high yields in relatively short times. The wood is valued as a raw material for many uses in the cellulose industry. The French and Italian pulp industries have thus been led to take in hand and develop on a large scale the planting of poplars.

However, poplars only reach higher yields than spruces, pine, or beech in places which particularly suit them. On lands where these other species still give relatively good yields poplars sometimes do not grow at all.

Hybrid black poplars need very special soil conditions; the

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experience of their ecologic extension has shown that this is not very great, and that the planting possibilities are limited. The water needs of poplars are extremely high. The following figures, given by Wittich, show the quantities of water required for the production of 1 kg. of dry matter:

Pine	170 liters
Beech	350 liters
Black poplar	500 liters

Besides, poplars need a rich and well aerated soil. The roots cannot tolerate lack of oxygen, and are sensitive to acid soils.

Favorable conditions for growth are found at the edges of ponds and brooks, or roads, etc. Forests in wet plains suit the cultivation of poplar particularly well. The acclimatized poplar is not exactly a forest wood, and careful fertilization is essential, as well as close watching of the plantation grounds. Attempts have been made to obtain, by crossing different species of poplar, less exacting varieties giving equally high yields and cellulose-rich wood (Stout and Schreiner hybrids, Oxford).

GUM

A few species of gum have reached Europe from Australia and New Zealand. The development of these fast-growing, high-yield species is limited by the need for a progressive acclimatization. The most favorable areas for the development of gum are the marshy areas of the western Sardinian coast. There are also large forests of gum in Provence and Gascony. But the experience of several decades of cultivation will be needed to select a variety of gum which may be cultivated under the climate of other European areas.

AILANTUS GLANDULOSA

The *Ailantus glandulosa* or "tree of Heaven," improperly called "Japanese sumach," grows very quickly and keeps its leaves late into the autumn. In spite of the strong and rather unpleasant smell of its flowers, it is planted along avenues. Its wood is used by cartwrights instead of ash and elm, although it is inferior. It is used in Japan for pulp manufacture.

This tree, which originates from Japan and northern China, has been lately introduced into Austria as a decorative tree, and has excited the author's interest. The technical literature contains a few records of cooking experiments on this wood. In 1924, the Forest Products Laboratory of Madison, Wis., made some sulphate cooking trials, but we have no details of the analysis of the wood and pulp, or of the mechanical and microscopic characteristics.

The ailantus has a rather short life which does not exceed 40 to 50 years; it may grow to 45 to 60 ft. The growth is extremely fast, especially when the tree is young, and nevertheless gives a very dense wood. The moisture-free density is 0.63, and the air-dry density (R.H. 15%) is 0.69.

According to Hartel, the fiber content is 60 to 70%, the average length of the fibers being 1.2 mm. (0.7 to 1.4 for aspen). The wall of the fibers are thick; their surface is irregular and serrated.

The ailantus multiplies easily by seeding and sprouting.

Whereas poplars need special soil qualities, these needs seem to be much less exacting for the ailantus. Regarding soil and climate conditions, it may be compared to the locust or white acacia.

The areas which might be devoted to the cultivation of this tree are therefore larger and better distributed, and include areas which were unfit for pulpwood cultivation up to now. Regarding large-scale plantations of ailantus the following details are known:

According to private information given by Mr. Socher, commissioner of woods and forests for the Burgenland (Austria), the ailantus has been chosen for planting especially for wind-screen formation in the Burgenland, which is the least woody region of Austria. Three hundred and seventy to four hundred acres per year are now being planted to this end. The choice of ailantus is due to the fact that soils of these areas are the poorest: they form regular steppes, which reach from the Burgenland to the Hungarian plain. The climate may be characterized as follows: low relative humidity, low rainfall, high summer and low winter temperatures, gravelly and sandy soil, with little humus, soil bacteria almost completely absent.

Nevertheless *Ailantus glandulosa* grows well, and no frost damage has been found so far. In the Burgenland, the ailantus is grown for pit props and driftwood. No planting has been done in higher areas so far. Next year, the Burgenland forest commissioners are to check the yield of these woods.

The forest commissioners have pointed out that the ailantus is foreign to our regions, and that, as there are no similar species in our forest, it cannot insert itself normally in forest life, which does not prevent its cultivation in artificial forests, forming pure plantations.

If we parallel what has just been said about the ailantus with what has been said about poplar and gum, we instantly notice the many advantages of the ailantus.

Experimental Pulping

An *Ailantus glandulosa* cut down in the autumn of 1954, was first left a few months on the spot. The trunk was barked and the inner bark stripped by hand, at the beginning of January, which was done without difficulty. Mechanical barking would therefore appear to be easy. The trunk was cut into 1-in. thick disks with a circular saw.

Each cook was made on disks taken from different points along the trunk. The chipping was done by hand.

Owing to lack of time, a complete analysis of the wood has not been possible. The ash content, dichloromethane extract, lignin, alpha-cellulose, and hemicellulose were determined.

A 5-liter stainless steel laboratory digester was used with electrical heating and temperature control. Cooking pressure and temperature were continuously recorded. To avoid local over-heating, the digester was slightly agitated every 15 min.

The respective densities of ailantus, spruce, and aspen are 0.69, 0.45, and 0.43. The weights of chips of the same size loaded into the same volume are in the same ratio as the densities. The yield from ailantus per cubic foot of digester may therefore be expected to be higher than the yield from spruce or aspen. As shown by the data given hereafter, the yield of cellulose given by calcium bisulphite pulping of ailantus is 50% or more. If the yield from spruce is taken as 45%, the capacity, for a given volume and equal cooking time, would be 190 against 100 lb. for spruce.

The following liquors were used: caustic soda, sodium bisulphite, sodium bisulphite spent liquor with make-up sulphur dioxides, and calcium bisulphite.

A simultaneous calcium bisulphite cook was afterwards made with ailantus and aspen.

After cooking, the chips were drained on a bronze wire, and washed repeatedly with cold water until neutral. The chips were then roughly defiberized for 15 min. with an agitator, and the pulp was vacuum-filtered on a porcelain filter. The screening was reduced to sorting out a few coarse shives. This refuse was always well under 1%. As early as the first year of growth, the development of boughs is such that the density of the nodes is practically the same as the density of the trunk. This allows total and uniform impregnation by the liquor, and gives uniform cooking. Some parts of the heartwood, which was rather voluminous were not completely cooked, and remained in the pulp as dark-colored shives, but the proportion was so small that they were also sorted out by hand.

Determination of Strength Characteristics and Brightness

The strength and brightness of the pulp samples were determined as follows:

The defiberizing was done according to method "Zellcheming 103." The beating was done in a Jokro mill at 6% consistency on 16 grams moisture-free dry pulp, according to method V/105. The speed was 150 r.p.m. The jars were taken out at regular intervals, and the pulp was defiberized for 2 min. in the standard defiberizer, before the handsheets were made. To determine the zero point of beating, raw pulp was defiberized in the standard defiberizer for 25 min.; according to method 104. The handsheets were made according to TAPPI Standard T 205-m on a Herman sheet machine, as the "Rapid-Koethen" sheet machine was not yet available at the time. The basis weight was measured on air-dry sheets. All determinations were made after conditioning the sheets at 65% R.H. and 20°C. The breaking length and elongation at break were measured on the Schopper tester, the bursting strength on the Mullen tester, the tearing strength on the Elmendorf tester, and the folding strength on the Schopper tester.

The brightness was measured according to TAPPI Standard T 217-m, on a Photovolt tester against a magnesia standard.

Details of Cooks and Characteristics of Pulps

Before we give the details of cooks and characteristics of pulps, we must emphasize that the data given are only the results of our first trial series, and that they are of a tentative nature, the optimum conditions of disincrustating for ailantus not having yet been determined.

The trial cooks were made under the supervision of F. Brauns at the Graz Institute. The main object was to work out a complete investigation program on the basis of the results obtained.

Soda Pulping. This was done with 6% caustic and 22.7% Na_2O on the moisture-free wood. After 1 hr. heating to 100°C., the cook has held at 100°C. for 1 hr.; then 3 hr. heating to 165°C. and $2^3/_4$ hr. at 165°C. Maximum pressure was 7.2 atm. gage.

The yield was 49.3% (moisture-free cellulose/wood).

Figure 1 shows how the mechanical strength varies with beating in a Jokro mill. The strength of ailantus pulps comes near to the strength of spruce sulphite pulp. The Photovolt brightness of the unbleached soda pulp before beating was 46°E.

Sodium Bisulphite Pulping. The liquor contained 5% total SO_2 and 1% combined SO_2. After 1 hr. heating to 100°C., the cook was held at 100°C. for 1 hr. The maximum temperature (135°C.) was maintained for 5 hr. The total cooking time was $8^1/_4$ hr. The maximum pressure was 7.4 atm. gage.

The yield of very soft pulp was 54% (moisture-free pulp/wood).

Figure 2 shows how the strength properties vary with beating.

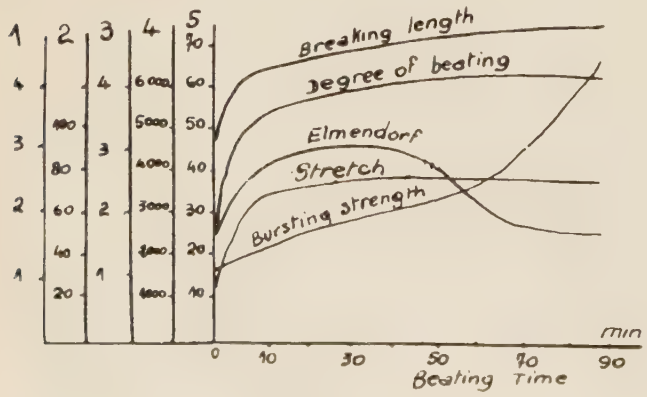

Fig. 1

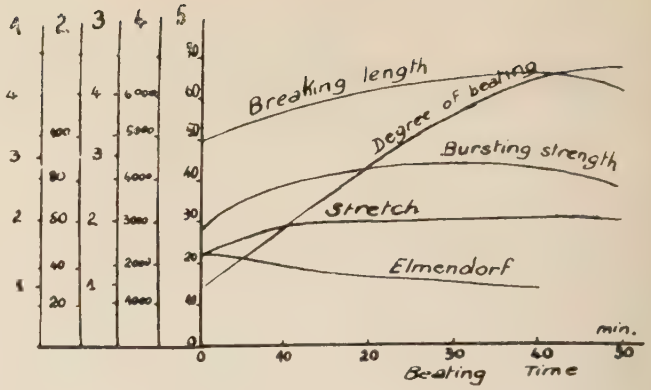

Fig. 2

The brightness of the unbeaten pulp was 72%.

Calcium Bisulphite pulping. The liquor contained 5.05% total SO_2 and 0.86% combined SO_2. After 75 min. heating to 100°C., the temperature was held at 100°C. for 1 hr.; the cook was then heated to 135°C. and held $4^3/_4$ hr. at 135°C. Total cooking time was $7^1/_4$ hr., and maximum pressure 8.3 atm. gage.

The yield of very soft pulp was 49.2%.

Figure 3 shows how the strength properties vary with beating. With better cooking conditions, the strength properties of the calcium bisulphite pulp could certainly be improved.

Simultaneous calcium bisulphite pulping (Ailantus + Aspen). The digester was baffled, one compartment being loaded with aspen, the other with ailantus. The liquor contained 4.77% total SO_2 and 0.81% combined SO_2. The total cooking time was $7^1/_4$ hr., with 4 hr. at 135°C., and a maximum pressure of 8.2 atm. gage.

The aspen pulp yield was only 42%, the ailantus pulp yield 54.5%.

A noteworthy point is that the brightness of the ailantus pulp was 57% or 11.5% above the brightness of the aspen pulp.

The following table shows the strength properties of both pulps, after beating to 20°S.-R.

	Ailantus	*Aspen*
Yield, %	54.5	42.0
Beating (Schopper-Riegler)	20°	20° (23 lb.)
Breaking load, kgs.	6.770 (15 lb.)	10.470
Breaking length, m.	4.140	6.400
Elongation at break, %	0.64	1.23
Bursting pressure, kg.	1.32 (18.8 p.s.i.)	2.83 (40.05 p.s.i.)
Tearing strength (Elmendorf)	48	59
Brightness, %	57.0	45.5

The following table summarizes the yield given by the various pulping procedures.

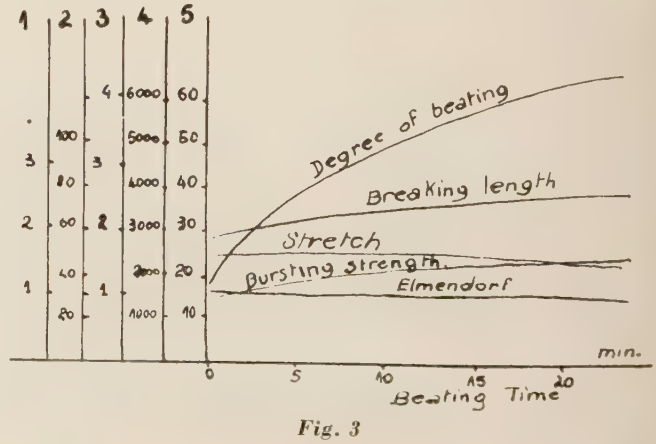

Fig. 3

Species	Pulping procedure	Yield, %
Ailantus	Soda	49.3
Ailantus	Sodium bisulphite	51.0–53.8
Ailantus	Calcium bisulphite	49.2–54.5
Aspen	Calcium bisulphite	42.0

Bleaching Tests

A mixture of three sodium bisulphite ailantus pulps, brightness 72%, was bleached with calcium hypochlorite. The consistency was 9.2% and the temperature 33° ± 2°; bleaching time 3¾ hr. Initial pH = 8. For 1.81% chlorine consumed (on moisture-free unbleached pulp), the loss was 6.17%; the bleached brightness was 80.5.

The bleached pulp is easier beating than the unbleached pulp. The strength of both pulps is the same.

Use of Ailantus Pulp for Rayon Manufacture

We sent a sample of bleached sodium bisulphite ailantus pulp to the Lenziger Zellwolle A.G. fibran mill, where Paula Sarten kindly studied its fitness for rayon making.

It must be emphasized here that the bleaching of ailantus pulp was done exclusively to ascertain its bleaching properties, and involved no special treatment for rayon-making pulp. The fact that the results were nevertheless good is due to the nature of the pulp itself.

The following analyses were made:

Alpha-cellulose	88.1%
Resins and gums	5.86%
Ash	0.22%
Copper number	1.72%
Copper solution viscosity	325

These data could easily be improved by a more adequate bleaching procedure. A mere 2% increase of the alpha-cellulose content would give an ideal rayon pulp. The resin content and copper number would be definitely lowered if the bleaching was done at a higher pH (about 10). The ash content could be lowered by a protracted acid treatment.

These data, which are far from being optimum, show that ailantus pulp may very likely be used as a raw material for the rayon industry.

CONCLUSION

1. *Ailantus glandulosa*, because of its fast growth, gives a yield of wood which is well above that of other pulpwood species under our latitudes.
2. Compared with hardwoods, ailantus is more easily barked.
3. Ailantus is easily pulped by alkaline or acid cooking, and gives high pulp yields. The high density of the wood allows a high capacity per cubic foot of digester space.
4. The unbleached pulps have a relatively high brightness.
5. The unbleached pulp is easily bleached with low quantities of chlorine.
6. The acid-cooked pulps were very soft, which shows that the cooking times were too long. The cooking time may therefore be much reduced.
7. Although the pulps were soft, the strength characteristics may be considered as satisfying, compared with other hardwood pulps.
8. It can be predicted that ailantus pulps can be universally usable in the paper industry as a substitute for aspen and other hardwood pulps.
9. It seems likely that ailantus pulp might be used in the viscous rayon industry.

The high smoothness of the handsheets shows that ailantus pulp may be used to improve surface qualities, especially for printing papers.

This pulp may partly replace spruce sulphite pulp in fine and semifine writing papers, in glassine and toilet tissue, etc.

Our next investigations will bear on a thorough chemical analysis of *Ailantus glandulosa* wood, and of the various pulps. We then mean to determine the best cooking conditions for the usual pulping procedures. We will make various bleaching runs and determine all the strength properties of the pulps. We will make grinding runs on ailantus wood, and endeavor to determine the fitness of the various chemical pulps and of ailantus groundwood for the manufacture of different kinds of paper.

Presented at the meeting of the TAPPI Overseas Discussion Group held in Paris, France, May 20–21, 1955.

An Appraisal of Semichemical Pulping Development

Roland O. H. Runkel

For some years there has been an increasing interest among papermakers of all countries in a new kind of pulp: semichemical pulp. As with many new processes, the discoveries of several decades back were finally followed by industrial achievements. This is not, therefore, a new process, as far as wood is concerned, but a new industrial achievement. Semichemical straw pulp has been produced for many years, sometimes on large scale, chiefly in Holland, but also in other countries, such as Germany and Italy. These pulps are lime-soaked and soda-cooked straw pulps, which must be included among semichemical pulps, owing to their chemical and physical characteristics.

In a short survey of the semichemical pulp problem, different approaches may be used. For instance, the history and present development of semichemical pulps might be described. The fibrous materials used for semichemical pulping might also be taken as a starting point, and the significance of semichemical or high-yield processes considered against the general background of the fibrous material supply problem. An investigation might be undertaken on the chemical or mechanical treatments which would best develop the chemical or papermaking properties of plant fibers and make their use cheaper in their various applications. In one case, the main point would be to study the chemical degradation of the fiber. The investigation could also be centered on disincrusting processes which allow the isolation of the fibers, while avoiding their chemical attack as far as possible. It would be possible to discuss the very interesting developments in continuous cooking techniques. A specialist of the waste purification question might dwell on this problem, which is very important in semichemical pulping. Finally, the semichemical pulp problem might be considered mainly in the light of the possible uses in paper and board making and of the qualities for which these pulps are best fitted and capable of future development.

However, in a short survey, the lecturer must keep to the main facts and give the most significant results of his own work. The author will therefore endeavor to speak only of the most important problems of the aspects of the semichemical pulp question mentioned above, which are characteristic of the field of this new and interesting material.

HISTORICAL

The author has been working for 30 years on unbleached and bleached semichemical pulps, and has thus been able to follow part of the historical development of the problem. Macerated straw pulp has been known for a very long time. Those who are interested in the history of this very old process may turn to the large technical literature. We will merely study the development of semichemical wood and wood refuse pulp since 1920.

RAW MATERIALS

It was not by chance that pulps of inferior chemical purity

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were neglected at a time when the paper industry had not yet been threatened with a shortage of pulpwood. It was only when the increasing scarcity of northern softwood supplies was noticed that the semichemical pulp problem was seriously considered. Then, some organizations in the main industrial countries, turned their energies into two main channels: (1) the use of low-value wastes from the forests and the wood industry and (2) the use as fibrous materials of plants which had been neglected so far, such as hardwoods, agricultural wastes, or wild herbs.

Great strides were made in these fields, so that laboratory work in the United States, France, Germany, Italy, and the U.S.S.R. gave tangible results.

The large number of plant materials found in the temperate, tropical, and sub-tropical areas, such as poplar, straw, bagasse, esparto, bamboo, gum, and the many species of the tropical forests, assumed an increasing significance for semichemical pulp manufacture. The raw materials which gave the greatest difficulties in conventional processing methods, for mechanical or chemical reasons, were found to be quite fit for semichemical pulping.

METHODS

The characteristic of semichemical processes is that the point of chemical delignification has been displaced by a more thorough mechanical disintegration, some features of conventional pulps being left out, but the yields being higher and the prices lower. These methods made continuous treatment possible which was an important factor of economical production for the semichemical pulp mills.

CHEMISTRY

For the chemical disincrustation of plants into semichemical pulp, they are treated with various reactives and under very different physical conditions. The two main methods now in use are: the neutral sulphite semichemical process (NSSC), widely used in the United States, and the cold soda process. The first of these is especially suited to the treatment of hardwoods, whereas the second is used for the pulping of gramineous plants and agricultural wastes. Both processes have great possibilities. As far back as 1926, in the course of pilot-plant experiments, and again in 1928, in large-scale experiments, the author found that the alkaline semichemical process was better suited to the treatment of hardwoods, such as beech, which are more easily disintegrated than softwoods, such as spruce. This fact may be explained on chemical grounds by the difference of lignin contents, and on morphological grounds by the different nature of the wood elements (tracheae and tracheids).

TECHNIQUE

The technical development of semichemical pulping has been favorably influenced in the United States and Sweden by the growth of the Asplund board industry. The Chemipulper and the Asplund refiner are instances of continuous chemical treatment.

The various beating devices (refiners), developed (mainly in the United States) by engineering firms such as Bauer, Sutherland, and Sprout-Waldron, are the result of research work directed toward a disintegrating action which would spare the individual fibers. The screeners such as "Centri-Cleaners" are useful for finishing the disintegration, and their part is all the more important as the proportion of shives in semichemical pulp is particularly high, as was to be expected. The "Supraton" machines and "Gutehoffnungshütte" disk refiners are the result of similar research work in Germany.

It appears, then, that the manufacture of semichemical pulps has brought about new technical achievements in the papermaking field, and led to the development of new machines, which are still being improved.

Table I. Chemical Yields and Characteristics of Unbleached and Bleached Beech Semichemical Pulps According to Runkel, 1930

Characteristics	*Composition of various tests* — *Extra bright pulp, Test IV*	*Extracted fibers, Test III*	*Chlorinated fibers, Test II*	*Raw fibers, Test I*	*Beech-wood*	*Remarks*
Yields	55.1	56.2	65.8	77.0	100	
Cellulose	42.5	42.5	42.5	42.5	42.5	According to Schmidt
Xylose acid sol. (+0, 15 methyl)	11.5	11.5	11.5	11.5	11.5	According to Schmidt
Easy soluble fraction	0.6	1.5	3.7	5.0	12.2	Calculated difference by Schmidt
Hexoses	...	...	...	4.3	4.3	According to König
Lignin with methoxyl	...	...	7.5	...	...	.....
Acetyl free lignin	...	...	...	12.8	20.8	According to Schwalbe
Total acetyl	...	...	...	...	5.6	Titrated from alkaline waste liquor, according to Fresenius
Methyl and carbohydrate	...	...	...	?	0.6	Calculated
Resins, proteins	...	...	...	...	2.0	According to König
Ashes	0.5	0.7	0.6	0.9	0.5	Titration
Gums	13.3	13.6	15.1	12.2	15.2	According to Schmidt
Furfurol	9.1	9.4	9.9	10.2	13.1	With barbituric acid, Gierisch
Total pentosans	16.0	16.6	17.3	17.6	22.7	Calculated according to Schwalbe-Sieber
Xylose	14.4	14.9	15.7	16.1	20.7	Calculated according to E. Schmidt
Total methoxyl	0.30	None titrated		5.0	6.1	According to Zeisel
Methyl	0.15	None titrated		2.42	2.95	Calculated from methoxy

PRODUCTS

By far the greatest part of semichemical pulp is at present used for corrugated board. But this should not prevent future development in other directions. By altering the chemical treatments and disintegrating methods, new uses will be opened up for semichemical pulp.

One trend of research will be the development of an efficient bleaching method for semichemical pulp, so as to get products which may compete with conventional pulps, and even excel them where hardwood, gramineous plants, and very small-sized vegetable wastes are concerned. Six mills already make bleached semichemical pulp in the United States. It has been qualitatively demonstrated that semichemical pulping of hardwoods and gramineous plants gave better products than conventional pulping methods. This had been evidenced by a series of laboratory results already obtained by the author in 1926 on beechwood, Table I, and is supported by the Pomilio-Celdecor process for gramineous plants, on the author's three-stage bleaching process. When new processes and techniques make it possible to bleach semichemical pulps

economically, new and important markets will open for their use in the papermaking field, notably for the production of high-quality printing papers. The economic optimum lies near a 55 to 60% yield for bleached hardwood semichemical pulp.

EXPERIMENTAL

We have already mentioned investigations which demonstrate that hardwoods and gramineous plants are better suited than softwoods to semichemical pulping. This holds for unbleached pulp production as well as for multistage bleaching (chlorine + hypochlorite).

There have been attempts lately to produce in one operation a fairly light-colored semichemical pulp. The neutral sulphite process proved particularly suitable. The latest development is the replacement of sodium base by magnesia base, as shown in the excellent book by Smolders, which summarizes work done at the Netherlands Experimental Station for the Utilization of Straw. This author found that both magnesium and sulphur dioxide were easily recovered by a relatively simple process. We must also mention the butanol-acetone fermentation of semichemical waste liquors.

We have endeavored to determine the influence of soda cooking temperature between 20 and 150°C. on the brightness of the pulp. Low-temperature products were the brightest, and brightness went down as the cooking temperature went up. It appears that the well-known color due to high-temperature cooking is due to lignin condensation products. To obtain an idea of the strength variation of pulps cooked at different temperatures, the samples were subjected to strength tests at various degrees of beating. These investigations indicate the possibility of using low-temperature semichemical pulps (20 to 60°C.) instead of groundwood, without bleaching, or with a very light sodium peroxide bleach.

Much research work is now being done on these cold caustic soda pulps. Satisfying results are said to have been obtained on beechwood in a Danish plant.

To quote other personal work, the author will mention trial runs made on sawdust. Research on the use of sawdust and shavings is being carried out in every industrial country. It is always based on the idea of recovering large quantities of fibrous material from industrial woodwork waste. Conventional minds in the cellulose industry are, of course, very skeptical towards the treatment of such a fine material as sawdust. This attitude is easily explained by the damage done to the fibers by the wrenching action of the saw, and by the total failure of conventional pulping methods applied to sawdust. The particle size of sawdust makes uniform cooking impossible, and leads to the formation of pockets which entirely escape the action of the liquor. However, the latest experiments have shown that sawdust can be treated successfully by chemical and mechanical means for semichemical pulp manufacture.

The highly interesting results obtained by Lewitin and Schwarz, and published in *Pulp & Paper Magazine of Canada* (1954), have demonstrated that the partial mechanical destruction of fibers in sawdust is a drawback only when the sawdust is not submitted to proper and adequate chemical and mechanical treatment. The experiments of Jayme had shown that, in sulphite pressure cooking, the fibers were damaged by the disintegration of the middle-lamella lignin and that this was not the case in sulphate pulping. Lewitin and Schwarz, starting from firwood sawdust, obtained a pulp by a multistage treatment (chlorine dioxide-NaOH) which was superior to commercial bleached sulphite. The same treatment, applied to poplar sawdust, gave a pulp with a strength equivalent to that of a corresponding sulphite pulp. This shows that the physical state of sawdust changes its behavior towards chemical attack and makes it extremely sensitive, but that its morphological state by no means implies a destruction making the pulp unfit for papermaking uses. The injuries of the middle lamella and the primary wall leave the cellulose-richer secondary wall bare, thus exposing the latter to hydrolyzing and oxidizing actions. These actions are very mild in the chlorine dioxide-1% soda treatment. Chlorine dioxide disincrustation is at present economically unfeasible, but it is quite possible that other less costly chemicals may have an equally mild action on the fibers.

Conventional digesters, even with liquor circulation, are to be rejected for semichemical sawdust pulping, whereas the continuous digesters normally used in semichemical pulping may be adapted to the treatment of sawdust.

Classification of Groundwood and Sawdust Pulp Fibers

Groundwood (J. Kisser)		*Sawdust pulp (E. Justusek)*	
Length, mm.	*Per cent*	*Length, mm.*	*Per cent*
0.1–0.5	59.0	0.1–0.5	59.7
0.6–3.4	40.4	0.6–1.0	26.7
3.5 and over	0.6	1.1–1.5	10.7
		1.6–2.0	2.3
	100.0	2.1–2.5	0.6
			100.0

We have made many experiments on sawdusts of various particle sizes, with and without addition of more bulky wastes (planing and barking shavings). Neutral sulphite semichemical pulping gave excellent results, with appropriate cooking liquor. For instance, breaking lengths sometimes exceeded 6000 m. When the percentage of chemicals is reduced, the strength of spruce sawdust pulps is lowered. The neutral magnesium sulphite process, with recovery of the chemicals, seems to offer remarkable possibilities for producing from sawdust bright and strong pulps, with many potential uses.

SUMMARY

The development of semichemical pulps is in full swing. The world production of these pulps is constantly increasing.

Since 1952 there has been a considerable increase of semichemical pulp production, and it may be said that we have here a new fibrous material, used first in the corrugated board industry, then probably as a substitute for groundwood in newsprint and which will eventually be introduced into high-class printing papers, as soon as the bleaching problem is economically solved.

The problems of cost are always the crux of all economic considerations. The latter are dominated by the high yields of semichemical pulps, up to 75 to 85% for unbleached pulp, 55 to 60% for bleached pulp, which is well above the yields given by chemical pulping methods. Another point in favor of the development of semichemical pulps is the realization of continuous pulping, which is now being done without difficulty under 9 to 12 atm. (130 to 170 p.s.i.) An economic difficulty is the recovery of neutral sodium sulphite waste liquors, which is possible only when the mill contains a sulphate plant. However, this difficulty seems about to be speedily solved by neutral magnesium sulphite treatment.

The use of agricultural wastes and gramineous plants is of the greatest significance for fibrous raw materials policy, especially in those countries which are poor in coniferous species and have a growing paper industry, as in Eastern Asia and South America. But the growing use of hardwoods and the large-scale treatment of mixed tropical woods will help to cover the ever-increasing needs of paper, and avoid the destruction of coniferous forests in northern countries.

Once the large-scale treatment of sawdust and shavings is fully worked out, economically and technically, the industrially advanced countries shall enjoy a new and important alleviation of the fibrous raw material supply problem.

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The Hemicelluloses of Sea Pine Wood (*Pinus pinaster* Soland): Separation of Uronic and Aldobiuronic Acids Obtained from These Hemicelluloses Through Hydrolysis

A. Roudier and L. Eberhard

The knowledge of the structure of hemicelluloses has greatly progressed in the last 3 or 4 years. For a better understanding of what follows, we will first summarize the present knowledge on this field, taking for instance the "xylan" of wheat straw, which is the most extensively studied of the hemicelluloses. It is understood that we use the term "xylan" for the sake of simplicity. This polysaccharide, the molecule of which is built of arabinose, glucuronic and monomethylglucuronic acids residues, is in fact a glucuronomonomethylglucurono-arabino-xylan.

The structure has been derived from the studies of G. A. Adams (*1*) in Vanada and of A. Roudier (*2*) at the "Laboratoire Central des Services Chimiques de l'Etat" in Paris. It includes a main chain, made of D-xylopyranose residues linked by β 1-4 glycosidic bonds. On this main chain are fastened short lateral branches, each made up of one arabinofuranose residue, linked by one 1-3 glycosidic bond (probably α), of one D-glucuronic acid residue, and of one 4-*O*-monomethyl-D-glucuronic acid residues. The glucuronic and monomethylglucuronic acid residues are linked to the main chain by α 1-3 glycosidic bonds.

The number of lateral branches varies, probably between zero and one per each xylopyranose residue (*2*).

The above structure has been suggested by the results of methylation studies. It is of interest to check these results by other methods. More particularly, as there always remains, even after applying the methylation method, a doubt about whether one is dealing with a mixed polysaccharide or a mixture of simple polysaccharides (i.e., each made up of one kind of sugar residue only) it would be desirable to obtain, by means of a suitable hydrolysis, mixed oligosaccharides, which are easy to study, to purify by crystallization, etc. This result is easily obtained in the case of uronic acid residues, as the carboxyl group on carbon 6 greatly stabilizes, against hydrolysis by a dilute acid, the glycosidic bond between these uronic acid residues and the neutral sugar residue. The hydrolysis of the polysaccharide by a dilute acid gives the following compounds (in the case of wheat straw "xylan") D-xylose, L-arabinopyranose (the furanose cycle not being stable in the free state), and compounds known as aldobiuronic acids, consisting of one uronic residue (glucuronic or 4-*O*-monomethyl-glucuronic acid) and of one xylose residue. The study of the structure of these aldobiuronic acids makes it therefore possible to check the nature of the bond between the uronic acid residues and the xylose chain.

As to the arabinofuranose branches, the problem is far more difficult. In this case, indeed, contrarily to what we have just seen concerning the uronic acid residues, the glycosidic bonds relating to a furanose residue are always much weaker toward acid hydrolysis (50 to 200 times, according to the hydrolysis constant) than the bonds relating to a pyranose residue. Therefore, hydrolysis with a dilute acid can never give mixed arabinose-xylose oligosaccharides, if the suggested structure is correct. A solution to this problem has just been given by Bishop and Whitaker (*3*), who have carried out the hydrolysis by means of the purified cellulase extracted by Whitaker (*4*) from the *Myrothecium verrucaria* mold. This enzyme cuts the β 1-4 glycosidic bonds between xylose residues but spares the bonds between arabinofuranose and xylose ones. The above authors have actually found that the hydrolyzate thus obtained from wheat straw "xylan" contained various mixed arabinose-xylose oligosaccharides. The specific rotations given by Bishop and Whitaker suggest strongly the presence of a bond between the arabinofuranose residues and the xylose chain; on the other hand the inspection of the table of the oligosaccharides obtained by these authors (*3*) shows that there is no uniformity in the distribution of arabinofuranose residues along the main chain, which agrees well with the variability of the number of these radicals, which we had reported previously (*2*).

The composite nature of wheat straw "xylan" is thus confirmed very well, and we have here a fine example of the increasing importance of the use of enzymes in the study of the chemical structure of polysaccharides.

It follows from the above that the study of hemicellulose structure may begin with a dilute acid hydrolysis, so as to get the aldobiuronic acids containing the uronic acid residues existing in the molecules of the hemicelluloses. This hydrolysis may even be carried out directly upon the plant organs studied, without any previous separation of the hemicelluloses, as these are much more easily hydrolyzed than cellulose. This has been done by Jones and Wise (*5*) on American aspen (*Populus tremuloides*) wood, by Gorrod and Jones (*6*) on Scottish pine (*Pinus silvestris*) wood, and by the same on black spruce (*Picea nigra*) wood. In each case these authors have obtained one and the same aldobiuronic acid 2-(4-*O*-monomethyl-D-glucurmosyl)-D-xylose.

On the other hand, Roudier had applied the same method to wheat straw and to various hardwoods, and had found various aldobiuronic acids in the hydrolyzate. Besides aldobiuronic acids containing xylose, he always obtained β-1-6-glucuronosido-D-galactose. This aldobiuronic acid is identical with the acid obtained from gum arabic, the structure of which has been studied by Hotchkiss and Goebel (*7*).

Roudier has also reported (*2*) the presence in hardwood hydrolyzates of aldobiuronic acids containing rhamnose.

We have now applied the same method to sea-pine wood (*Pinus pinaster* Soland).

Pinewood sawdust (500 grams), extracted with alcohol-benzene was treated with 6000 ml. N/2 H_2SO_4 for 15 hr. under reflux. The liquid, neutralized with barium carbonate and filtered, was reduced to 500 ml. by vacuum distillation, and 5000 ml. alcohol were added. The precipitated barium salts were separated by centrifuging, and purified by redissolving in water and reprecipitating with alcohol until the neutral sugars were eliminated.

Two such operations gave a total of 14.5 grams of barium salts.

A preliminary chromatographic analysis on paper having shown the complex character of the mixture of barium salts, it became necessary to try and separate them in adequate quantities for investigation. Jones and Wise (*5*) had fractionated the acid portion of their aspen wood hydrolyzate by chromatography on a carbon column, followed by a chromatography on a cellulose column. Roudier (*2*) had separated the uronic and aldobiuronic acids from wheat straw by means of a large number of paper chromatographies.

Preliminary trials showed that chromatography on paper (and therefore on a cellulose column) was inadequate for a complete resolution of the mixture. We therefore sought a better method of separation. A combination of chromatography on ion-exchange resin and on thick filter paper (Whatman no. 3) gave satisfactory results.

Five grams of the barium salt mixture were first dissolved in water and treated with an excess of ion-exchange resin Amberlite IR-100 (H), so as to free the acids. The acids solution, concentrated by vacuum distillation, was absorbed on 6 grams of Amberlite IR4B (OH), finely ground and dried. The wet mixture was poured on the top of a column (l = 200 mm., d = 45 mm.) of Amberlite IR4B ($HCOO^-$). This resin had previously been ground in the wet state (acetate form) and screened under water on a 200

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screen, the finest portions being eliminated by settling. The liquid chromatogram was then developed with N/10 formic acid, and the fractions were collected by means of an automatic collector.

The course of the separations was followed by sampling every 5 or 10 tubes and analyzing by means of paper chromatography. The fractions containing the same product were united and concentrated by vacuum distillation, at the lowest possible temperature. Some fractions, which contained several compounds, where refractionated by chromatography on an adequate number of large sheets of Whatman no. 3 filter paper, the solvent being a 9:1.5:0.5:2 (by volume) mixture of ethyl acetate, acetic acid, formic acid, and water.

The results given in Table I show how the various substances behave on the paper chromatograms.

Let us consider the order of separation of the fraction, as indicated by the numbers of the tubes in the automatic collector in the case of ion-exchange resin chromatography, and by the relative coefficient of travel R_{gln} (based on glucurone) in the case of paper chromatography. It will be seen that the order is quite different in either case, the methods of separation being based on entirely different principles. The main factor is the strength of the acids in ion-exchange chromatography, whereas it is the relative solubility in water and in an organic solvent in partition chromatography on paper. We find that, roughly speaking, the separations occur in the opposite order: the aldobiuronic acids, weaker than the uronic acids, are washed out first on IR4B resin, whereas the uronic acids with the lowest molecular weight and containing the least OH groups travel quickest on paper.

This reversal in the order of separation is only approximate, however, and some of the substances present are easily separated by one method and not by the other. Such is the case, for instance, of the compound contained in fraction A, which is washed out of the resin column long before fraction D, whereas it travels on paper approximately at the same speed as the aldobiuronic acid in fraction D3. On the other hand, fraction D contains five components, which can be separated on paper, but cannot be separated on resin. Glucuronic and galacturonic acid cannot be separated on paper, while they can be fairly easily separated on resin, etc.

These examples show the advantage of combining both methods.

We have also mentioned on Table I the colors given by the various components of the paper chromatogram with aniline acid phthalate reagent. These colors vary a great deal and may indicate the nature of the sugar residues present in the molecules. Thus, aldobiuronic acids consisting of one pentose residue and one uronic acid residue by progressive heating of the wet chromatogram, give first the orange color due to the uronic acid, then the purple color due to the pentose. Aldobiuronic acids consisting of one aldohexose residue and one uronic acid residue, such as the glucuronosido-galactose of fraction D, give a black-brown color, the orange of the uronic acid being added to the greenish-brown of the hexose.

In the first work, the investigation of the separated aldobiuronic acids had to be limited to a hydrolysis, followed by the identification of the components. The yield of the hydrolysis is very low, because of the strength of the bond between the sugar residues and of the breaking down of the uronic acids. The yield is slightly better when hydrolysis is preceded by a methanolysis, according to the technic of Jones and Wise (*5*) which we have followed.

Thus, the analysis of the hydrolyzates by paper chromatography has shown that two of the aldobiuronic acids (D2 and D3) consisted of one xylose residue and one glucuronic acid residue. The latter is identified on the chromatogram by the spot given by glucurone, as glucuronic acid alone gives a lactone of this type when heated in a dilute

Table I. Separation of Uronic and Aldobiuronic Acids Obtained by the Partial Hydrolysis of Sea Pine (*Pinus pinaster* Soland) Wood

Chromatography on IR4B resin (H-COO)			*Chromatography on Whatman No. 3 paper*[a]					
Fractions	*Nos. of collecting tubes*	*Dry weight of fractions, g.*	*Fractions*	*Dry weight of fraction*	*Color given on paper with aniline acid phthalate*	R_{gln}[b]	*Component of the fraction*	*Hydrolysis*
A	0–200	0.000	...	...	Purplish	0.12	Aldobiuronic or aldotriuronic acid	Xylose + uronic acid
	201–60	0.1503						
B	261–271	0.0449	...	...	Light brown	0.19	Aldobiuronic acid	Rhamnose + uronic acid
	272–300	0.0864						
C	301–400	0.4973	...	...	Orange then purplish	0.39	Aldobiuronic acid	Xylose + monomethylglucuronic acid
						1.24 (very weak spot)	?	
	401–439	0.0169	D_1	0.023	Black brown	0.047	Aldobiuronic acid	Galactose + glucurone
			D_2	0.014	Orange then purplish	0.079	Aldobiuronic acid	Xylose + glucuronic acid + glucurone + very mobile spot
D	440–540	0.2017	D_3	0.0085	Orange then purplish	0.11	Aldobiuronic acid	Xylose + uronic acid + glucurone
			D_4	0.033	Orange then purplish	0.54	Aldobiuronic acid	Xylose + monomethylglucuronic acid
			D_5	A few mg.	Brown	1.24	?	
	541–580	0.0335						
	581–700	0.0400						
E	701–830	0.2198	E_1	0.0519	Orange-brown	0.29	Galacturonic acid	
			E_2	0.0067	Light brown	0.52	?	
			E_3	0.029	Reddish brown	0.84	Monomethylglucuronic acid	
F	831–1040	0.3653	...		Orange-brown	0.29	Galacturonic acid	
G	1041–1250	0.0580	...		Orange-brown	0.30	Glucuronic acid	
H	1251–1300	0.0088	...		Orange-brown	0.30	Glucuronic acid	

[a] The separation on Whatman No. 3 paper has been made only on a portion of fraction D and E. The weights given in this column merely give an indication of the relative quantities of various components.

[b] R_{gln} = ratio between the length of travel of the compound and that of glucurone on a paper chromatogram (Whatman No. 1; solvent 9:1.5:0.5:2 ethyl acetate-acetic acid-water, by volume).

acid. Two other aldobiuronic acids consist of one monomethylglucuronic residue and xylose (C and D4).

The aldobiuronic acid of fraction D1 consists of one galactose residue and one glucuronic acid residue. This compound behaves on the chromatogram exactly like the -1-6-glucuronosidogalactose of gum arabic, and is very probably the same.

The aldobiuronic acid of fraction B contains one rhamnose radical.

These partial results show the complex nature of the hemicelluloses of sea-pine. The molecules of these hemicelluloses contain glucuronic acid residues, linked in at least two different ways to a xylose residue, and monomethylglucuronic acid residues, also linked in two different ways to a xylose residue. They also contain glucuronic acid residues linked to galactose, and other uronic acid residues linked to rhamnose.

Galacturonic acid, which crystallized in fraction F, and which we have identified by the characteristic Ehrlich reaction, probably comes from the hydrolysis of pectic acid. Gluruonic and monomethylglucuronic acids come from a partial hydrolysis of the bonds between the residues of these acids and neutral sugar residues.

We have also found several unknown substances in the mixture under study, especially a compound travelling very quickly on paper (R_{gln} = 1.24) in fractions C and D5. This may be a lactone or another product of dehydration formed during the treatment, but this hypothesis must be checked.

A point which seems most important is the absence of mannose residues in the aldobiuronic acids obtained. A very great proportion of mannose residues is known to exist in softwood hemicelluloses, and it was to be expected that uronic acid residues would be linked to some of these mannose residues. This seems not to be the case, as we have obtained no aldobiuronic acids containing mannose residues.* There may be two types of polyholosides in lignified plant tissues, some being neutral, i.e., containing only neutral sugar residues, such as cellulose and mannans, others being acid, such as the "xylan" containing uronic acid residues.

This may have a theoretical, but also a practical interest as the properties of cellulose pulps containing this or that polysaccharide might be foreseen.

This observation, together with others made in previous papers (*8*, *9*, *10*), effect of arabinofuranose residues on the solubility and swelling in water of "xylan," ion-exchange properties of hemicelluloses, due to the presence of uronic acid residues, is enough to justify even from a practical industrials standpoint, the continuation of extensive research on the structure of hemicellulose.

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* Small quantities of an aldobiuronic acid containing mannose may have escaped our notice, but at all events if such an aldobiuronic acid is present with mixture investigated it can be in a very little proportion only. Mannans would then contain only a very small proportion of uronic acid residues if any.

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A Simple Apparatus for Measuring the Freeness of Pulp

F. C. Aldred

At several stages during the manufacture of rayon pulps, pulp is separated from the water used for washing or transporting it, by means of a rotary filter. In the case of the commonly used fibers, such as spruce or beech, the capacity of a given filter is well known from past experience, but in the case of pulps which have never before been used for pulp manufacture, it is difficult to predict how they will behave. Freeness tests indicate whether the capacity of a filter is likely to be greater or smaller than it is with a known pulp, but do not enable an estimate of the capacity to be made.

Again, it is well known that damage to the fibers during bleaching can have a deleterious effect in the behavior of the pulp in the initial stages of the production of viscose rayon. In the older processes employing steeping presses, quite a small amount of damage can cause serious floating troubles, and lead to non-uniform alkali-cellulose. In the more modern slurry-steeping processes, an increase in the content of fiber fragments can cause a serious reduction in the rate at which the presses can be operated. The amount of damage which can cause these troubles is not easily detected by the usual freeness test.

These are two examples of the inadequacy of the usual freeness test. Other theoretical and practical objections have been listed by Campbell (*1*) and more recently by Ingmanson and Whitney (*2*). To these may be added the fact that high degree of precision which is required in the construction of the instrument inevitably results in its cost being high. If the instrument is constructed of materials which will resist adequately the action of the various liquors which have to be separated from the pulp during the bleaching process, the cost is even higher.

Recently, interest has been focussed on drainage tests, especially in the case of unbeaten pulps, and it appears that some such test will eventually displace the Schopper-Riegler and similar tests. In the circumstances, the instrument described below may be of interest.

The instrument was developed to meet an urgent demand for some method of differentiating between various hardwood pulps, and it was essential that it should fulfill the following conditions: (1) the results obtained should be simply related to the behavior of the pulp on a rotary vacuum filter; (2) the instrument should be sensitive to small amounts of fiber damage; (3) the amount of pulp required for each test should not be greater than 5 grams; (4) the instrument should be capable of being used with strong acids, alkalies, and oxidizing agents at temperatures up to 100°; (5) the instrument should be of simple construction, and preferably easily transportable.

The instrument which was evolved did meet these requirements, and has now been in use for several years, during which time it has proved to be useful in connection with several investigations concerned with the production of rayon pulps from hardwoods. It has not so far been used with pulps beaten to the extent required for the production of paper.

PRINCIPLE OF THE METHOD

In a normal rotary vacuum filter, a slurry of pulp at a consistency of about 1.5% is forced on to a wire gauze by atmospheric pressure. The fibers are retained by the gauze, and the water passes through. In this way, a layer of pulp is formed on the gauze, and within a very short time, forms the effective filtering surface. From this point onwards, the rate at which pulp can be filtered is independent of the dimensions of the gauze, but depends on the properties of the pulp,

F. C. Aldred, Courtaulds Ltd., Coventry, England.

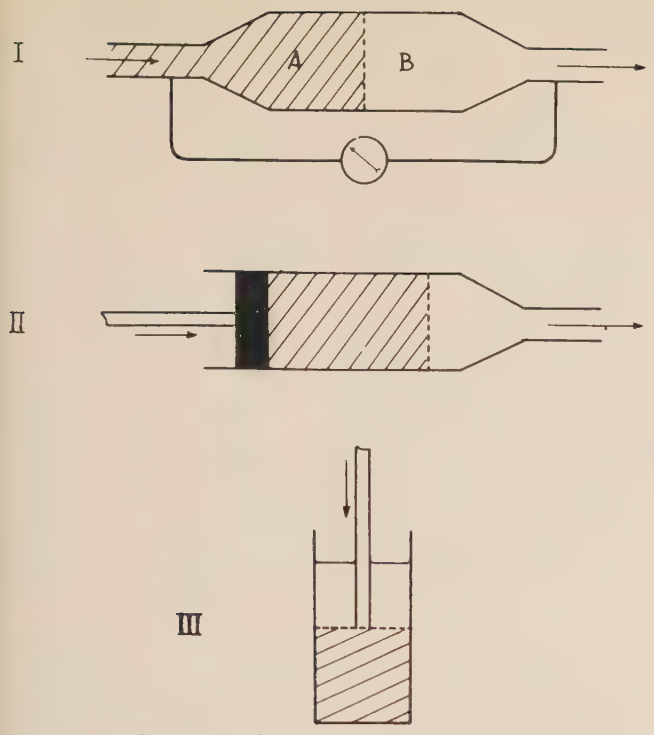

Fig. 1. Stages in the development of the apparatus

the consistency, the pressure difference across the filter, and on the viscosity of the aqueous medium.

The action of such a filter can be imitated by an arrangement such as that shown in Fig 1-I. A slurry of pulp at the required consistency is fed at constant pressure into a chamber across which is fixed a gauze diaphragm. The pulp is retained by the gauze, and the water escapes at B. The pressure across the gauze is measured by a gauge. An arrangement such as this has been used by Ingmanson and Whitney for the investigation of the influence of various factors on the filtration process, but the apparatus is too complicated, requires too much pulp, and is too slow in producing results to be used as a routine test of pulp quality.

The arrangement could be simplified if the driving pressure were to be applied by a piston working in a cylinder, the end of which is closed by a piece of gauze. Such an arrangement, shown diagrammatically in Fig. 1-II, suffers only from the drawback that it is difficult to manipulate.

If the positions of the fixed gauze and the solid piston are interchanged, giving the arrangement shown in Fig. 1-III, the manipulation of the apparatus is considerably simplified. The vertical cylinder sealed at the bottom forms a vessel for the preparation of the slurry. The constant pressure is provided by a suitable weight acting on the permeable piston. The movement of the piston can be observed directly, or the movement of some reference point on the piston rod can be recorded. Provided that the walls of the cylinder are smooth, and the piston is not too tight fitting, the frictional resistance of the piston and the plug of pulp which quickly forms, is negligible compared with the resistance of the flow of water through the plug. In practice, it is found that if the cylinder is made from a piece of ordinary glass tubing, in the normal range of consistencies and pressures, the apparatus behaves as though the resistance to movement of the piston is due entirely to the resistance to flow of water through the plug of pulp.

DESCRIPTION OF THE APPARATUS

The cylinder consists of a piece of heavy-walled Pyrex tubing, internal diameter about 32 mm., and about 35 cm. long. The dimensions of the tube are not particularly important, but with this size of tube, the weights required to give pressures in a suitable range are not too heavy, nor too light compared with the weight of the piston and the piston rod. The wall thickness of the tube need not be very great to withstand the pressures involved, but it is desirable to have the glass as thick as possible to limit the possibility of accidental breakage. When selecting tubing for the purpose, pieces with uneven bores should be rejected. Usually tubes are slightly greater in diameter at one end than the other, but this is no disadvantage provided that the difference is not greater than about 0.5 mm., and the wider end is made the bottom of the cylinder. The bottom end of the cylinder should be ground square with the sides of the tube, the top end is best smoothed in a flame and flared slightly.

The bottom end of the cylinder is sealed with a rubber stopper. It is convenient to choose a stopper a size too large for the purpose, and to cut it in the lathe so that there is a limit to the extent to which it can be pushed into the tube. This enables the cylinder to be used for measuring the volume of slurry, thus simplifying the preparation of a slurry of the required consistency. For this purpose, a line is engraved around the tube at a level corresponding to 200 ml. The cylinder is mounted in a vertical position, with the rubber stopper resting on a solid base, so that the pressure in the cylinder does not tend to push it out. To avoid corrections for temperature variations, the cylinder is preferably mounted in a thermostat.

The piston consists of a disk of stainless steel about 3 mm. thick, and about 1 mm. less in diameter than the inside of the cylinder. By means of a countersunk hole in the center, the disk is riveted on to the end of a piece of stainless steel rod, 6 mm. diameter and about 100 cm. long. After riveting, the lower surface of the disk is turned flat and square with the rod. The disk is drilled with as many holes about 3 mm. diameter as possible, to allow unrestricted flow of water through the disk. To the under side of the disk is fitted a disk of gauze the same diameter as the disk, of about 40 mesh. This, in turn, is covered with a disk of gauze of about 100 mesh, its diameter being as close to that of the tube as possible. The gage of the gauze should be as fine as possible, so as to keep the friction against the sides of the cylinder to a minimum. The mesh of the gauze is not very critical; identical results have been obtained with 40, 100, and 150-mesh gauze. The pieces of gauze can be tied to the disk with strands of fine wire or with nylon monofil.

Over part of its length, extending from about 15 cm. from the piston, the rod is graduated with divisions 5.00 cm. apart. At least three such divisions are necessary, but it is convenient to have four or five, so that the apparatus can be used over a greater range of filtration rates.

As a support for the slotted disk of lead used as weights, a collar is fixed to the upper part of the rod, about 35 cm. from the end. With a cylinder of the size recommended, a weight of about 8 kg. provides a pressure of 1 kg. per sq. cm. This is too heavy for routine tests, and instead it is recommended that a series of weights be made of such a size that pressures of 0.1, 0.2, and 0.3 kg. per sq. cm. can be obtained.

The upper end of the rod passes through a guide consisting of a piece of thin laminated plastic sheet drilled with a hole which is an easy fit for the rod. The guide is fixed in such a position that the rod is vertical when the piston is in the tube.

For observing the movement of the rod, two cross wires are required, both in the same horizontal plane, and one behind, the other in front of the rod. Adjustment of the height of the cross wires should be provided to allow for changes of cylinder or rubber stopper. The height of the cross wires is adjusted so that the bottom mark on the rod is level with them when the piston is just touching the surface of the slurry in the cylinder.

A perforated stainless steel disk fixed on the end of a stainless steel rod is used to disintegrate and disperse the pulp in

the cylinder. The rod should be about 10 cm. longer than the cylinder, and about 4.5 mm. in diameter. The disk should be about 5 mm. smaller in diameter than the tube, and about 1.5 mm. thick. The size of the perforations should be about 4.5 mm. for disintegrating the pulp, and for dispersing it, either about 7 mm. diameter for short fibered pulps, or in the form of slots radiating from the center to the edge of the disk for long fibered pulps.

When assembled, the cylinder should be vertical, and the rod should move up and down freely along the axis of the cylinder. There should be enough play in the guide at the top of the rod to enable the piston to be lifted out of the cylinder and swung to one side to permit the stirrer to be inserted.

METHOD OF OPERATION

The cylinder is half-filled with water, and the amount of pulp required to give the desired consistency is added. It is preferable to allow the pulp to fall on to the stirrer, and then to be slowly lowered into the water, in order to expel as much air as possible. The pulp is thoroughly disintegrated, taking care that no air is sucked into the slurry, and water is then added to bring the level up to the graduation mark. Using the appropriate stirrer, the pulp is now evenly dispersed throughout the slurry, and the stirrer removed without disturbing the dispersion. This can be accomplished by means of a series of short rapid up and down movements of the stirrer. Any pulp remaining on the stirrer is shaken back into the cylinder, and, if necessary, the stirrer is rinsed in the surface layer of the slurry. It is a convenience, and does not affect the results, if the pulp in the surface layer is gently pushed down, giving a few millimeters of clear water at the surface in which to rinse the stirrer.

The piston is now lifted from its rest, inserted into the cylinder, and carefully lowered until it just touches the water. With practice, it is now possible to immerse the piston without trapping air bubbles beneath it. It is then lowered gently, so as to form a pad of pulp which will seal the piston around the edges. When this has been achieved, the piston is pushed down to the bottom of the cylinder, and the pulp pressed to release any air bubbles which may have been trapped. The piston is then removed, and the pulp dispersed uniformly immediately before a reading is taken.

As the piston does not fit the cylinder perfectly, the fall of the piston cannot be timed from the surface of the slurry. The movement of the piston must be restrained each time, over the first few millimeters, in order to form a satisfactory seal. This is no disadvantage, because the movement of the piston is quite uniform over the whole of its travel, as may be seen from Fig. 2. The movement of the piston is adequately represented, for all the pulps which have been examined, by the relationship:

$$\frac{d_2^2 - d_1^2}{t_2 - t_1} = K$$

where d is the distance travelled by the piston in time t, and the constant K, the filtration rate constant, is a function of the characteristics of the pulp, the pressure, the consistency and the viscosity of the medium. To measure K, therefore, it is merely necessary to time the fall of the piston over some arbitrary distance insuring, of course, that $d = 0$ when the piston is at the surface of the slurry. With the rod graduated as described, d_1 can be 5, 10, or 15 cm., and $d_2 - d_1$ 5 or 10 cm. depending on the filtration properties of the pulp.

After replacing any water lost when the piston is removed it is desirable to repeat the measurement to ensure that the pulp was uniformly dispersed and that all bubbles were eliminated. If air is trapped in the slurry, a series of readings will give decreasing times of fall, and the expulsion of the air by pressing the pulp at the bottom of the cylinder should be repeated. If it is impossible to obtain a dispersion of the pulp which appears uniform, the distance over which the measurement is made should be increased. Similarly, if the time is too short for convenient measurement, the distance would be increased, and a correction made in the manner described below.

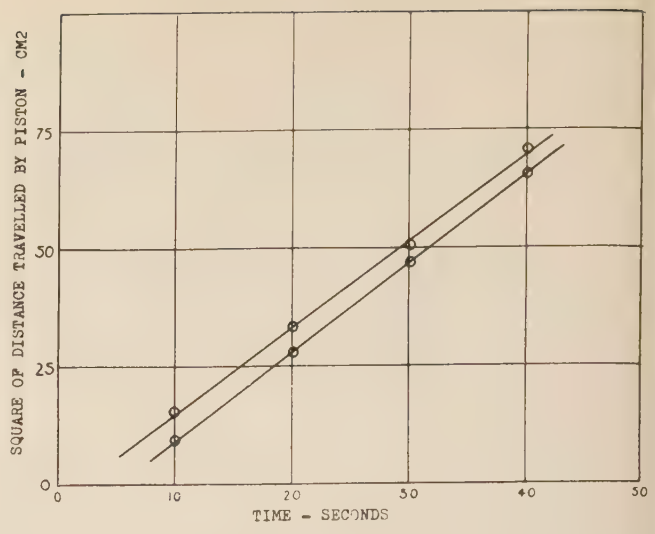

Fig. 2. The relationship between the distance traveled by the piston and time

THE EFFECT OF PRESSURE VARIATIONS

The pressure used on rotary filters vary from a few feet of water up to almost atmospheric pressure, but it is not convenient to measure filtration rates over the whole of this range with the apparatus described. At very low pressures wall friction becomes important, and at high pressures, the weight required is too great for the girls, who normally carry out the test, to lift. However, numerous experiments have shown that the relationship:

$$1/K = C/p + S$$

where C and S are functions of the consistency and the viscosity of the medium, holds over the pressure range 0 to 1 kg. per sq. cm. It is therefore possible to carry out determinations at three convenient pressures, and to calculate the rate constants at other pressures if so desired. As C and S have different values for each pulp, it is undesirable to carry out determinations at a pressure much different from that which is of interest, unless this correction is adopted.

The above expression, which is quite empirical, implies that, although at very low pressures, K is roughly proportional to the pressure, at very high pressures, K approaches a constant value, $1/S$. For this to happen, the increase in the resistance of the pad of pulp would have to balance exactly the increase in the force driving the water through the pad. As it is unlikely that this is true over a very wide range of pressures, the above expression must be regarded as an approximation to the true relationship between K and pressure.

For the purpose of differentiating between samples of pulp, it is normally unnecessary to take account of the different behavior at different pressures, and it is suggested that, for all normal purposes, a pressure of 0.1 kg. per sq. cm. will be found to be suitable.

THE EFFECT OF VARYING THE CONSISTENCY

The range of consistency over which the apparatus can be used is limited at the lower end by the difficulty of forming a seal between the piston and the cylinder wall, and at the upper end by the difficulty in securing a uniform dispersion of the pulp. With rayon pulps, the limits are be-

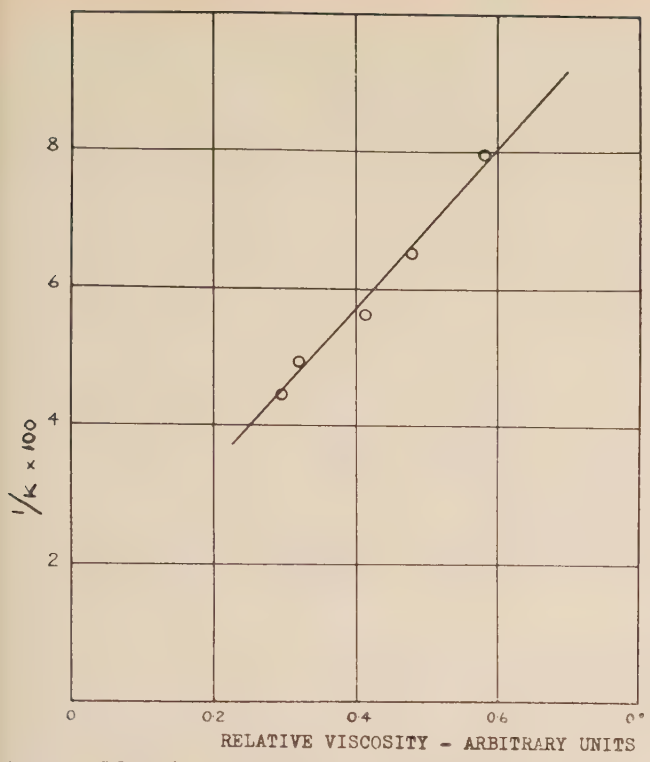

Fig. 3. The relationship between the filtration rate constant and the viscosity of the water at various temperatures

tween about 0.8% and 2.0%. All the pulps which have been examined have been easily handled at a consistency of 1.5%, and it is suggested that this should be adopted as a standard value. As quite large variations in filtration rate can be accommodated by suitable manipulation of the distances between which the piston is time, there is little to be gained by varying the consistency from one test to another. The relationship between the filtration rate constant and consistency is not a simple one, so that it is difficult to reduce measurements taken at one consistency to another standard consistency.

In most cases that have been examined, the relationship:

$$K = K' - K''(c - a)^n$$

where c is the consistency and K', K'', and n are characteristics of the pulp, has been found to hold. However, the fact that n varies from pulp to pulp necessitates many determinations at different consistencies before the rate constant at another consistency can be calculated.

THE EFFECT OF TEMPERATURE VARIATIONS

Measurements have been carried out on bleached and unbleached pulps over a range of temperatures, and it has been found that the relationship between the rate constant and temperature is similar to the Arrhenius equation, i.e., the logarithm of the rate constant varies as the reciprocal of the absolute temperature. This suggests that the factor determining the change of rate with temperature is the change in the viscosity of the medium. In Fig. 3 the rate constant is plotted against the relative viscosity of water at the temperature at which the measurement was carried out. It will be seen that this forms a satisfactory relationship for the correction of results obtained at one temperature to some standard temperature and also for the calculation of rate constants when dissolved substances raise the viscosity of the water.

DISCUSSION

The method of determining the filtration rate constant which has been described has been found to be a satisfactory method of detecting damage to fibers during bleaching, and has been found to be a useful guide in predicting the behavior of pulps prepared from woods which have never before been used for pulp production. The method is simple to carry out, and the results sufficiently precise for most purposes (standard deviation about 5%).

The method has never been applied to pulps intended for the production of paper, and the correlation between the filtration rate constant and freeness has not therefore been investigated. It would be expected to be more useful than the freeness test in the low freeness range and also in the high freeness range.

One of the surprising results of the limited investigation which has been carried out into the effect of altering the variables in the test, has been to show that a single constant cannot be expected to give very much information about a pulp sample, if it is to be used under conditions which are different from the test conditions. Thus two constants are required to describe its behavior at different temperature, two more are required to account for pressure variations, and three constants are required for an approximate description of the effect of consistency variations. It is little wonder that papermaking is still largely an art!

THE MEASUREMENT OF BRIGHTNESS

In order to measure the brightness of a sample of pulp, it is necessary to prepare a surface which has the same composition as the bulk of the material. It is well known that when sheets are prepared on the fourdrinier, there is a movement of the fines relative to the fibers, so that the two surfaces do not have the same composition as the bulk of the pulp. In general, brightness tests on such sheets give values which are too high, owing to the loss of fines at both surfaces of the sheet. Normally the surfaces are in any case too rough to permit easily reproducible brightness measurements to be made.

Various methods have been proposed for the production of test sheets in the laboratory. In all these cases, the pulp is slurried with water, and a sheet is formed either on a fine gauze or on a piece of filter paper. Apart from the difficulty in producing uniform sheets by these methods, in all cases the movements of fines during the filtration of the fibers is pronounced, resulting in sheets, one side of which has too few fines, and the other side too many fines.

This may be understood by considering the mechanism of formation of the sheets. Initially the slurry of pulp is quite uniform, and ideally, remains uniform until the filtering surface is reached. At this point, the fibers are restrained, forming a loose network of fibers, through the interstices of which the water flows, carrying the fines with it. The fines are eventually stopped at a point where the pressure of the slurry has compacted the network of fibers sufficiently. If the sheet is being formed on a gauze, the fines may be washed from the lower surface of the partly formed sheet, and escape with the water. If the sheet is formed on a filter paper, the paper retains the fines which would be lost in the early stages of the formation of the sheet on a gauze.

At the upper surface of the sheet, the composition is the same as that of the bulk of the pulp when the surface of the slurry reaches it. If the movement of the water could be stopped at this point, the upper surface of the sheet would have the desired composition. Unfortunately, it is not easy to remove the water without at the same time removing some of the fines.

In order to prevent the movement of fines in the upper surface, it is necessary to prevent the movement of the water surface away from the surface of the sheet, and to carry out the operation under a pressure which is great enough to compact the sheet sufficiently to prevent the movement of fines during the pressing of the sheet. The apparatus which has

been described for the measurement of filtration rate is admirably suited for this purpose.

When the movement of the piston is carefully started and a high pressure (about 1 kg. per sq. cm.) is used to move the piston, there is no loss of fines with the filtered water, but there is some movement of fines near to the surface next to the gauze. This surface is therefore not suitable for brightness measurement. The fines in the small element of slurry at the bottom of the cylinder, which will eventually form the other surface of the sheet, have no chance to move away from the surface. In the first place there is no movement of water away from the surface and in the second place, owing to the high pressure used, the possibility of the movement of fines just below the surface is much reduced.

Various other advantages arise from the use of this method of forming the sheet. The stopper at the bottom of the cylinder can be covered with a piece of thin polythene film cut from an unused bag, so that the sheet is formed on the uncontaminated surface of the polythene. The sheet can then be pressed and dried without even removing it from the film, thus eliminating all possibility of contamination of the surface which is to be measured. As there is no movement of the water during the formation of the sheet, and as the uniformity of the dispersion of the pulp can easily be checked before the sheet is formed, the formation of the sheet is particularly uniform even when thick sheets are prepared, and the surface is consequently smooth.

The effect of the movement of fines is particularly marked in the case of a highly bleached pulp containing fines of poor color. A sample of a commercial rayon pulp made from beech gave a brightness value of 96 when measurements were made on the original sheet. When the brightness of a sheet prepared in the manner proposed by Valeur (*3*) was measured, it was found to be 89, compared with 92 for a sheet prepared by the method now proposed. Some of the pulp was fractionated using a 200-mesh screen, and in this a fines fraction, comprising 2% of the pulp, was found to have a brightness of 72, whereas the remaining pulp had a brightness of 96, the measurements in both cases being made on sheets prepared in the manner described below. In this case, measurements carried out on the original sheets gave a false impression of the purity of the pulp, and the sheet prepared by the conventional method gave the impression that the pulp was less pure than it actually was.

For the preparation of samples for brightness test, the size of the glass tube should be suited to the particular brightness meter used, but the length should be about 20 cm. It is convenient to use a separate piston for the purpose, fitted on the end of a rod about 40 cm. long. The piston can be covered with any size of gauze finer than about 40 mesh, and a double layer as described for the filtration test is not really necessary.

It has been found that a suitable basis weight for the sheets is about 1000 grams per sq. m. Sufficient pulp to give this basis weight is placed in the cylinder with sufficient water to give a consistency of about 1%, and the pulp carefully dispersed. The piston is then inserted, and a pad of fibers carefully formed on it. A pressure of several kilograms per square centimeter is now produced by pressing on the piston rod by hand, and the pulp forced to the bottom of the cylinder. Holding the piston in position, the cylinder is inverted over the sink, and the water poured away. Before removing the stopper from the cylinder, the pulp is pressed by hand in this inverted position, the end of the piston rod resting on the bottom of the sink. The stopper can now be removed, and the sheet, adhering to the polythene film, pressed further. The film is placed on a smooth metal surface, and the test sheet is covered with several pieces of smooth blotting paper. Pressing then produces a test sheet with an even surface suitable for brightness measurement.

In the case of all the rayon pulps which have been examined, it has been found that if the amount of water remaining after pressing is less than 70% of the weight of dry pulp, then drying in the oven has no further effect on the brightness. It is therefore possible to avoid drying, with a consequent saving in time, and probably some improvement in reproducibility. The relationship between water content and brightness is shown in Fig. 4. When the samples are dried before testing, it is found that there is a slight decrease in brightness as the water content before drying is reduced by pressing. It is therefore recommended that the sheets should be pressed as dry as possible, leaving not more than 0.7 part of water per part of dry pulp.

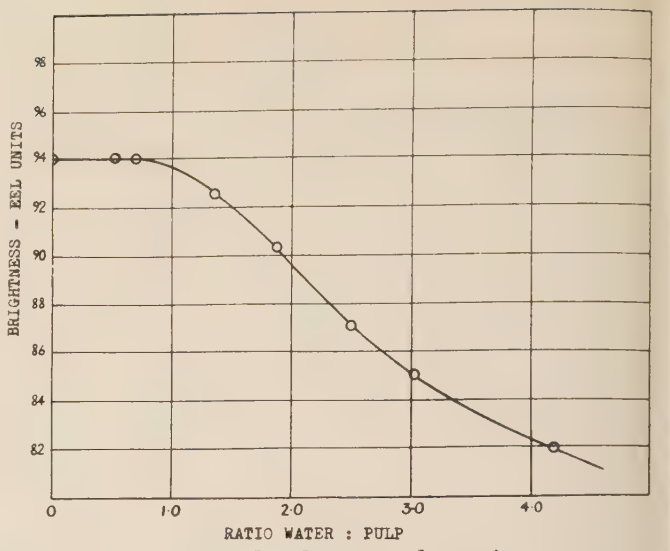

Fig. 4. The relationship between the moisture content of a test sheet and its brightness

The water used for preparing the test samples should be as pure as possible. Freshly distilled water is preferable but, if the water has to be stored for some time before use, it should be tested by filtering about a liter of water through each square centimeter of a piece of filter paper of suitable size for brightness measurement. The brightness of the filter paper should not be significantly altered by this treatment.

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Presented at the meeting of the TAPPI Overseas Discussion Group held in Paris, France, May 20–21, 1955.

The Sulzer System of Water Extraction for Paper Machines (Condensation)*

Robert Thomann

A METHOD of aspirating the air-and-water mixture from paper machines is described in which liquid-ring pumps serving individual suction points are replaced by a central blower.

The air-and-water mixture aspirated from the paper machine first goes to a preseparator, where the water is separated off. The air then passes through a cyclone separator which eliminates the last droplets, though leaving it saturated with water vapor. It is then compressed by the blower in several stages from vacuum to atmospheric pressure. Compression

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* See *Tappi* 38, No. 6: 365–373 (June, 1955).

is polytropic, the temperature of the air leaving the blower being higher at higher vacua.

Whereas conventional liquid-ring pumps delivered a practically constant volume of air, which decreases only at very high vacua, the air volume delivered by the radial blower may vary within wide limits without much change of vacuum. This permits intermediate branches to be used for partial vacua without any interaction between them. In this way the various vacua required for the paper machine can be obtained with good efficiency and without throttling losses. The resulting limitation of the vacuum also reduces wear on the wire.

The good efficiency and the elimination of throttling permit a considerable power saving. In addition, the energy required for the blower drive is almost entirely contained in the exhaust air in the form of heat. This hot air, with a relative humidity usually under 1%, can be used in the drier section. Steam requirements in this section are thus reduced by the equivalent of the blower input, making the system extremely economical. Moreover, the injection of cold water for condensing purposes into the air coming from the separators reduces the suction volume and input of the blower.

Multistage blowers are available in two designs. For small paper machines they have a vertically split casing, and the intermediate branches can be placed as desired. These small blowers are manufactured in large series and are very easily adapted to initial or changing conditions in paper mills. For larger air volumes radial blowers with horizontally split casings are used. These have fixed intermediate branches. So far over 200 installations have been supplied for all capacities. Experience has proved the practical efficacy of the system.

Suction Couch Rolls—Some Observations on Their Performance and Effect on the Paper

I. F. Hendry

Some years ago, the author's company arranged for an investigation into the method of operation of suction couch rolls. During this investigation a lot of photographs were taken which have thrown new light on the effects which these rolls have on the paper. It was felt that they contributed quite a lot to our knowledge of the wet end of the paper machine and its working.

The results obtained have not been presented elsewhere but the theories which they suggest have been touched upon in other papers. There are three papers which are of outstanding interest in this connection. These are those presented by Nissan (*1*) and Rance (*2*) at the recent TAPPI conference on the fundamentals of the paper machine, and a paper which will shortly be presented by Rance, Robinson, and Baggallay (*3*) to the Technical Section of the Canadian Pulp & Paper Association. All these papers are very general and deal with a greater range of subjects than the one presented here.

In order that the paper shall present an integrated whole, it consists of three parts: the historical background of suction couches, the observations which we made, and theories which we have put forward.

HISTORY, LITERATURE SURVEY, AND GENERAL PRINCIPLES

Most of the history of suction boxes is given in Arnot's paper (*4*), and in Heys papers (*22*, *26*).

The suction roll was evidently a logical development of the suction box. Suction boxes were invented in the late 1820's, and after they came into general use methods were sought to stop their abrasive effects on the wire. This was first attempted by giving the boxes roller bearing surfaces, though it was found difficult to maintain the suction with these. Next, papermaker's ideas went to a suction box which should revolve with the wire. Bentley and Jackson tried out a polygonal rotating box, and then in 1897 Alexander Black of Invergowrie, Forfar, patented a rotating suction box. This was almost identical with the suction roll we know today. In 1909 William Hulse Millspaugh, of Ohio, took out a patent for "Improvement in Suction Rolls for Paper Machines." These improvements were all concerned with keeping the stationary box stationary and with sealing it against the roll. These improvements have continued. The modern suction roll is, however, almost exactly as Black designed it. Black and Millspaugh both intended their suction rolls to replace suction boxes. They both abandoned this idea (why, is not clear) and used the suction roll in place of a couch roll. One of the first was put in at Varzin in 1909. At the time of Arnot's paper (1923), he had heard of no favorable opinions of the use of suction rolls.

Other types of rolls were the Margalt, patented in 1909, in which the suction box was fixed in relation to the shell; the Hellström roll, patented in 1917; and the Blyth roll. The Heys rolls, produced in 1922, consisted of a perforated roll with longitudinal holes. The suction was applied from the side and required complicated packing arrangements.

Although it is stated above that the suction roll was a locigal development from suction boxes, the very first suction box was actually a suction roll. This idea of using suction occurred to John and George Dickinson in 1822. They use it in their cylinder mold machines, and George Dickinson had the idea of using a cylinder mold as a fourdrinier machine suction roll. It is noticeable that this was used as well as a couch. The difficulties of packing were too great, however, and as a result papermakers went on to suction boxes. When the suction roll returned, as we have seen, it very quickly became used instead of the couch roll.

PRINCIPLES OF DESIGN

The first couch rolls to be invented were 4 ft. $^{9}/_{16}$ in. in diameter as this was the only size of non-ferrous tube available. They then progressed to about 18 in. which was the limit before centrifugal casting was developed. Now rolls are being made up to 60 in. diameter.

The ends of the box were sealed. This design was not successful because the friction between the inside of the shell and the sealing strips took the stationary box round with the shell. This difficulty was overcome by Mr. Millspaugh who in 1908 patented a suction roll with stops holding the vacuum box rigidly in position. This has remained the basis of the Millspaugh suction roll ever since, and all other improvements have been in the quality of the engineering. Suction rolls are now cantilevered from the back of the machine for easy wire removal, and have several vacuum compartments in the box, plus a high velocity air compartment if needed.

The modern suction couch roll has a well fitting vacuum box which can easily be rotated while the machine is running. The box has two suction compartments together with a high velocity box, and the holes are spirally drilled and countersunk.

WATER REMOVAL AND SHADOW MARKING

The work done in this investigation was intended to solve only one question—do suction couches remove any water? The results obtained were so inconclusive that the general question was then asked—what is the function of a couch? The search for an answer to this question is described in this paper.

First all old reports on the working of suction couches were examined. The results that were found are listed below:

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1. Wet beaten 90-grams per sq. in. paper being run at 150 f.p.m. (forward drive).
Solids ratio before couch 1 to 8.3
Solids ratio after couch 1 to 7.43
Water removed by couch 0.87 lb. per lb. fiber
Machine output 504 lb. per hr.
2. Fairly free beaten 90 grams per sq. m. paper run at 300 f.p.m. (forward drive).
Solids ratio before couch 1 to 7.5
Solids ratio after couch 1 to 7.22
Water removal by couch 0.28 lb. per lb. fiber
Machine output 1007 lb. per hr.

No details were available as to where this moisture went, as the figures are based on moisture contents only.

However, another mill did some similar work on a for ward drive machine. They found that running 44 gram-per sq. m. paper at 370 f.p.m., 2000 lb. per hr., the couch extracted 0.75 lb. water per lb. fiber, and running 20-gram per sq. m. tissue at 570 f.p.m. (1400 lb. per hr.), the couch extracted 2.5 lb. water per lb. fiber. The interesting feature here was that all this water was thrown off the roll and none of it was extracted in the pump separator.

Some qualitative observations were also obtained. A mill running an 88-gram per sq. m. ledger found that a suction couch was less effective than a top couch. Running 24-gram per sq. m. air mail, however, the suction couch was more effective than the top couch. They found that, on this wet beaten paper, an increase of vacuum from 5 to 7 in. water gage caused a 3% increase in water extraction.

A further trial with the forward drive tissue machine gave an extraction of $5^1/_2$ lb. water per lb. fiber; of this water, 66% was thrown off from the roll and 33% was taken out in the separator on the suction pump.

Another mill did an experiment running with a tight and slack draw after the couch roll. Here, they found that the web was distinctly drier with a tight draw, the fiber ratio being 1 to 4.9, compared with 1 to 5.7 with the slack draw.

Finally, to complete the known results a mill making a wet beaten paper on a machine with a forward drive roll found the following:

Fiber ratio before couch roll 1:8.25
Fiber ratio after couch roll 1:7.63
Fiber ratio on wire 30 in. later 1:8.05

Thus the couch was extracting 0.62 lb. water per lb. fiber, but an amount of water corresponding to 0.50 lb. water per lb. fiber was being re-absorbed on to the web.

None of the published literature gave any concrete figures for water removal, so, to summarize, the following results were available on which to base our work.

1. The moisture content of the web is less after the suction couch than before.
2. There is evidence that a suction couch actually sucks very little water through into the pump.
3. When running with a forward drive roll, water is re-absorbed by the web *after* the suction couch.
4. The web after the suction couch is drier with a tight draw than a slack one.

The above summary of known facts caused a change in the aims of this work, and the project became no longer one of finding out the efficiency of the suction couch, but one of answering the following question: "What is the function of a suction couch?"

EXPERIMENTAL WORK

It was decided that the work would be done with a stroboscope and a high-speed camera.

The stroboscope used was one which emitted flashes at high frequency varying as desired from 120 to 18,000 flashes per min. This lit up the portion it was desired to view and had the effect of causing any repetitive pattern to remain stationary. Thus, with it, the couch holes, etc. could be observed.

The camera was an ordinary high-class plate camera coupled to an electronic flash giving an exposure of 1/5000th sec. which made it possible to record the stroboscope views.

Our observations were taken on three paper machines. The first, referred to as machine A, was a greaseproof machine with normal suction couch design, running greaseproof at about 500 f.p.m. The second, machine B, was a normal machine running banks, bonds, and ledgers at 300 to 500 f.p.m. The third was a tissue machine running with a forward drive roll an unorthodox lick-up felt design at about 600 to 800 f.p.m.

The first part of the work consisted of direct observation and photography on machine B. The machine had 16 in. mercury on the couch. The first thing observed was a slight pattern on the paper as it left the couch. The next thing was that the holes in the couch roll on the return side appeared to have water in them, but the lands were fairly dry. The third thing was that on the return portion of the wire there were patches corresponding to the couch holes. These patches were dry where there had been a hole and wet where there had been land.

Next the same observations were made on machine A. Here the results were more startling, so we tried running this machine with a tight, medium and slack draw. With a tight draw marking is very pronounced, with a medium draw it is less, and with a slack draw it is nonevident. We have further postulated—and evidence points to the fact—that the web is dry where it has been over the lands, and wet where it has been over the holes. Also the whole web is wetter with a slack draw. Altering the draw did not affect the markings on the return wire which remained constant. An interesting point was noted, when the paper leaves the couch raggedly. It appears that the web leaves the wire above the lands sooner than above the holes.

On the breast side of the couch the lands are fairly dry and the holes wet.

The next observations were made on machine C with three different settings of the vacuum box on the couch roll proper: setting 1 was normal, setting 2 with the vacuum box tilted back 5°, and setting 3 with it tilted forward 5°.

With the box in the normal position (setting 1), there was a small spray in the outgoing wire nip and a very small throwoff from back side of the couch roll.

With the couch suction box tilted back 5° there was difficulty in maintaining the suction and the water removal reduced considerably.

With the suction box forward 5° the water removal was considerably increased—the majority being thrown off as a spray. Considerable shadow marking could be seen on the underside of the paper.

Finally, with the ordinary straightforward suction couches, in all cases turning off the vacuum caused the web to run round the wire and break at the couch. With a suction couch with a forward drive roll turning off the suction did not make much difference except to reduce slightly the water removal.

Resume of Observed Results

1. When a suction couch is in use there is very little evidence that it removes water, except insofar as water is thrown off. Very little water passes into the pump separator.
2. All suction couches produce "shadow marking" effects. The paper after leaving the couch is wet where it has been over a hole and dry where it has been over land.
3. On all suction couches the return wire is marked: dry where it was over a hole and wet where it was over land.
4. With a straight suction couch the shadow marking and water removal are both highest when the paper web is removed just at the sealing strip.
5. If the paper is allowed to travel further round the couch the pattern becomes blurred and the web becomes wetter.

6. With a forward drive roll, the paper re-absorbs moisture if it is allowed to remain on the wire after leaving the sealing strip.

7. With a forward drive roll the maximum water removal was obtained when the lick-up felt vacuum box and suction couch vacuum box were aligned.

8. This water was thrown off the roll either at the outgoing wire nip or on the return side.

9. With a forward drive roll the wire removes a proportion of fiber from the web. This fiber is usually found where the holes in the couch have been.

10. The couch shell on the return journey has a water film on the land and some signs of water in the holes.

THE THEORY OF COUCHING

The ten statements given above are all rather remarkable and all worthy of consideration. The better to explain them the fundamental principles of couching must first be considered. First and foremost, couching is simply this: *the removal of the web from the wire.* It has nothing at all to do with water removal, although, because it is a process which requires the movement of water, it has come to be associated in recent years with that function.

To understand the couching action it is necessary first to realize that the web is firmly entangled in the wire cloth. This is easily seen on any slow-running machine. It is simple to detach a strip of wet web from the wire immediately after the last flat box, but within a few inches the web has become completely keyed down to the wire and is irremovable. The action of the flat boxes has been explained previously and the author does not intend to elaborate now, but it is known that this fixing of the web to the wire is done by elastic absorption of water from the wire back into the web.

Obviously, since it is impossible simply to pull off the web, couching involves more than this. The above observations form a key to the process. A very good example of what happens can be observed on sheets made on a laboratory sheet machine and then couched off. If the suction is maintained right to the end, it will be seen that fibers have been removed from the sheet and are interlocked in the wire. If the wire is flooded with water just before couching, no fibers will be torn from the sheet.

Again we can consider what happens with hand-made paper. After the sheet has been formed and has drained under gravity, the mold is inverted, and is pressed downward on to a saturated felt. The downward pressure forces water upward into the wire-cloth of the mold, with simultaneous consolidation and strengthening of the web from which the water has been expressed—an action similar to the dandy roll action already discussed earlier. The mold is now lifted, and the water lying within the wire cloth floods down, releasing the web from the wire cloth by a wash-off process. This wash-off not only releases the web from the grasp of the surface tension forces of the thin film of water between web and wire; it also helps to detach and release fibers entangled with the wire-cloth.

When we come to machine-made paper we have the same effect. Over the flat suction boxes, the web is compressed considerably, and water is sucked into the boxes. A lot of this water is left in the wire, but the elastic expansion of the web after the boxes removes all the water from the wire back into the web again, leaving the wire moisture-free. The effect of a top couch roll is to compress the web still further and to push water through the web into the wire. A lot of this water is carried round on the bottom roll—the drive roll— of the nip and is forced through the wire flooding the underside of the web. This flooding helps to release the web from its entanglement with the wire and thus facilitates its release.

At high speeds this arrangement breaks down, and the suction couch was adopted to facilitate transfer at these speeds and their efficiency for doing this has undoubtedly been the real reason for their universal adoption. The way in which a suction roll helps transfer is as follows.

The suction draws water through the web into the wire and into the couch holes. It has been shown by laboratory experiments that this suction is not enough to empty the wire of water and furthermore, immediately on the release of the suction, the water is blown back into the wire both by the incoming air and by centrifugal force. As a result, the wire is flooded with water and a water film thus exists between the web and the wire, giving easy removal of the web from the wire. Thus, the couching action of the suction couch depends on the fact that water is flung back into the wire. This is why there are differences in action over the land of the suction couch and over the holes. Over the land the water in the wire is held by the considerable surface tension forces between the wire and the lands of the couch roll. It would therefore require considerable force for the web to remove the water from the wire, and in fact the water remains in the wire, so that the web over the lands comes off comparatively dry. Over the holes, however, there is the sudden rush of air out of them due to the release of the vacuum, and there is the outward flow of water due to centrifugal force. This allows the web which was over the holes to re-absorb water from the wire, leaving the wire dry and resulting in the wet pattern which appears on the web.

This mechanism explains the shadow marking on the tight draw. However, we have observed that with a slack draw the web becomes uniformly wet, having apparently re-absorbed water from over the land areas. This is quite possible, and we have shown that such water would be replaced on the lands by water ejected by centrifugal force from the couch holes.

Furthermore, on machines with forward drive rolls the water is thrown out of the couch holes immediately so that there is swift re-absorption of water by the wire and considerable interlocking of fiber in the wire. This was greatest when the couch was working most efficiently, i.e., there was less water left for the web to re-absorb. Couch roll and the web can be seen sticking out where it had been over a hole.

These then are our theories of action of a suction couch roll: a couch is for couching, not water removal and it works as follows:

Ordinary Suction Couch: (1) The rush of air through the web at the box forces water into the wire and into the holes of the couch roll. (2) After the vacuum seal the water in the wire above the holes is replaced by air rushing in. It is therefore free to be reabsorbed by the web. The consequent elastic expansion of the web keeps it into the wire. (3) If the web remains on the roll the web above the lands starts reabsorbing water from the wire. This is replaced by more water from the holes. (4) The wire remains dry above the holes and wet above the lands.

Forward Drive Roll: With the forward drive roll water is

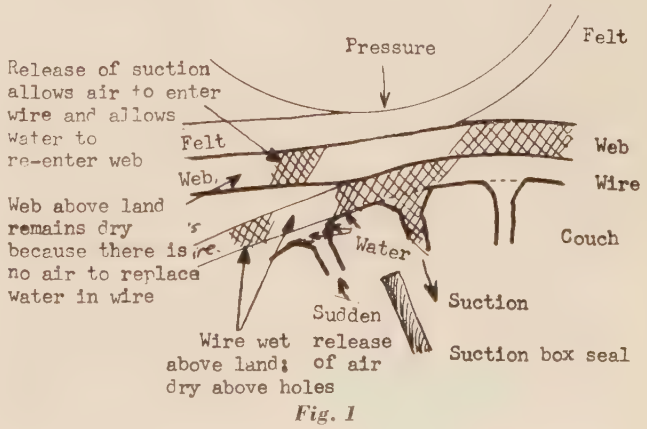

Fig. 1

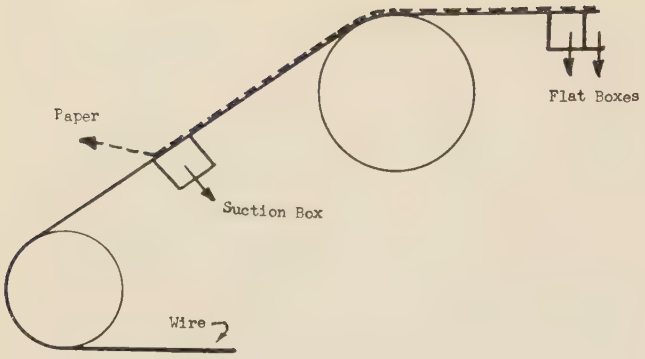

Fig. 2

removed primarily by pressure. It is forced through the wire where the holes of the couch are and is discharged as spray. Where the web is over a hole it is forced into the hole and the water is immediately re-absorbed by the web on leaving the wire. Where it is over land, there is a film of water between the web and wire. This film is retained in the wire by surface tension acting between the roll and wire, and there is perfect partition of the web from the wire. Here also, the web above the holes leaves wet and that above the land leaves dry. In this case there is considerable attachment of the web to the wire above the holes and fiber removal takes place. Figure 1 shows what the author believes happens.

CONCLUSIONS

The final conclusion is that all that a couch does is to allow the wire to be removed from the web by putting a film of water between the web and the wire. It does this most inefficiently.

As a result of this the author's company has patented what they consider to be the perfect couching device. It is simply a suction box placed on the wire as shown in Fig. 2. It has been patented fully for one reason only—it works.

A film of water is produced between the wire and web at the outgoing sealing strip of the suction box in Fig. 2. The web comes off perfectly. There is no adhesion of web to wire, and finally, because the web has no wet spots in it, it is considerably drier than with a suction couch.

LITERATURE SURVEY

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The author would like to take this opportunity of expressing his thanks to the directors of Wiggins, Teape & Co. (1919) Ltd., for permission to publish this paper, and to H. F. Rance, manager of research, for allowing him access to some unpublished work of his on the subject from which a lot of the theory has been taken. The author is also grateful to Derek Knight, chief technologist at Buckland Papermills, Dover, whose project this really was, and to the other mills in the Wiggins, Teape Group who have allowed him to take photographs at considerable risk to their paper machines.

The Retention by Paper of Sulphur Present in Anionic Urea Formaldehyde Resin and the Migration of Resin During Drying—Tests with Radioactive Sulphur

F. L. Hudson, H. James, and J. L. Putnam

During the last 15 years much information has been published on the use of urea and melamine formaldehyde resins to give "wet strength" to paper. A wet-strength paper remains reasonably strong even when saturated with water. While the wet tensile, wet burst, and wet rub are the most important properties affected by the resin, there has been some interest in the retention of resin in paper when it is added at the beater or at the wet end of the machine. The determination of nitrogen by the Kjeldahl method is simple and data based on this method have been published (*1–5*) but the retention figures obtained in this way should really be called nitrogen retentions. The other main constituent of the resin is formaldehyde and, although formaldehyde retentions are not published in the references cited, it may be assumed that they are of the same order as the nitrogen retentions but a little lower. Formaldehyde is lost on the drying cylinders as well as in the backwater.

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ANIONIC RESINS

Resins used for beater or wet-end additions must be substantive to paper fibers; straight, unmodified urea formaldehyde resins are not particularly effective in this respect and numerous methods for modifying the resins have appeared in the patent literature. Resins treated with alkali metal sulphite, bisulphite, or formaldehyde sulphoxylate have achieved some commercial importance (*6*, *7*, *8*).

THE RETENTION OF SULPHUR

The authors of this note were interested in the retention in paper of the sulphur in resins of this kind. Various proportions of bisulphite or sulphoxylate may be used but the amounts are usually quite low, of the order of 2 to 8% sulphur on the weight of resin solids. Preliminary calculations showed that, even if the sulphur retention was as high as the nitrogen retention, it would be difficult to estimate the amounts concerned by analytical methods, particularly as other papermaking additives contain sulphur.

It was found that radioactive sulphur, containing sufficient S^{35} to give a reasonable counting rate with the expected retention, was available in quantities sufficient for laboratory trial, and experiments were therefore put on to determine the retention of sulphur in sheets made on the laboratory sheet machine. Ten grams (anhydrous basis) sodium sulphite with an activity of 1.25 millicuries per gram of sulphur (3.16 mc. in all) was obtained from Harwell. Using this sodium sulphite a modified urea-formaldehyde resin was made at Oldbury. This resin was reasonably near to commercial products in quality and was used to make three sets of handsheets, under the following conditions: (a) $2^1/_2$% resin solids on kraft pulp, beaten to 430° Canadian freeness and containing 3% alum ($^{16}/_{17}$% grade); (b) $2^1/_2$% resin solids on kraft pulp acidified with hydrochloric acid only to pH 4.5; (c) $2^1/_2$% resin solids on bleached sulphite pulp containing 3% alum.

By "solids" total active resin content is understood. The British standard sheet machine (*11*) was fitted with a circulating water system and the backwater was adjusted to pH 4.5 in each set, using hydrochloric acid. Twenty-four sheets were made in each set. A set of blank sheets, without resin, was made using 3% alum and acid to pH 4.5.

The sheets were pressed once between blotters for 5 min. at 50 p.s.i. and then dried on a small steam-heated brass cylinder with a surface temperature of 115°C. Three blotters were therefore used in the making and pressing of each sheet, two for couching and one additional one for pressing. Each sheet was dried directly against the steam cylinder while still in contact with the blotting used for couching. The wire side of each sheet was therefore next to the drying cylinder.

Eight sheets out of the 24 in each set were tested at Oldbury for tensile strength and were also analyzed for nitrogen to estimate the nitrogen retention. This figure is taken as the percentage of nitrogen in the sheet expressed as a percentage of the nitrogen originally added to the pulp, after due allowance for blank tests. The wet-tensile tests were done on strips which had been soaked for 2 hr. in neutral tap water at 20°C.

The sulphur retention was determined on the remaining 16 sheets by comparing Geiger figures on them with similar figures on hand-sized blank sheets containing resin. Some blank sheets were soaked in a solution containing 1 part resin syrup to 100 parts water, passed through a wringer and weighted. The pick up was estimated from this weight and checked by analyzing the sheets for nitrogen.

The beta radiation from eight sheets from each of the sets (a), (b), and (c) was counted at Harwell with an end window Geiger counter, type EHM 2, in contact with the paper surface. The other eight sheets were tested at the Chemistry Department, University of Birmingham, using a similar Geiger counter. In this case the paper was placed in a fixed position about 5 mm. from the window.

The figures obtained are listed in Table I. Strength figures obtained on the same pulp with a commercial anionic resin are included for comparison.

The blotters used were also tested but the amount of sulphur retained in them was negligible.

The figures in Table I indicate that the sulphur retention is about half the nitrogen retention. The bleached sulphite was not tested without alum as it is already known that anionic resins are not retained to any important extent under such conditions. The sulphur retention was least in relation to nitrogen retention in set (b) containing no alum.

Table I. Wet Strength, Nitrogen Retention, and Sulphur Retention in Laboratory-Made Sheets

	(a)	(b)	(c)	*Commercial resin*
Pulp	Kraft	Kraft	Bleached sulphite	Kraft
Canadian freeness	436	436	424	436
Alum, %	3	Nil	3	3
Breaking length, km.				
Dry	10.1	10.55	5.45	10.2
Wet	2.56	2.63	1.35	2.78
Wet dry, %	25.8	24.9	24.8	27.3
Nitrogen retention, %	45	42	30	48
Sulphur retentions, %				
Harwell	25	18	16	. . .
Birmingham	23	19	17	. . .
Counts on wire side ÷ counts on top side	2.22	1.96	2.55	. . .

MIGRATION OF RESIN

It was found as soon as these sheets were counted that they were very two-sided, as shown by the count ratios in the table above. With the 60-gram sheets there appeared to be at least twice as much sulphur on the wire side as on the top side. The actual concentration difference was probably greater than this as the beta-particles entering the counter do not all originate from the surface facing it. Some come from the inside of the sheet and a few pass through it. Further experiments showed that the effect was greater with 120-gram than with 60-gram sheets. Some 120-gram sheets were split, after drying, into sheets of roughly equal substance. Tests on these showed that the activity, and therefore the sulphur concentration, did not increase uniformly through the thickness of the sheet but was concentrated mainly on the wire side. The effect was also shown to be due to drying—there was only a small difference between the two sides when sheets were dried overnight on stainless plates in air at room temperature according to the standard pulp testing method (*11*). An autoradiograph made at Harwell showed a mottled pattern similar to that obtained when a sheet containing an acid dye, such as orange II, is dried too quickly. The one sided drying treatment, more intense in its early stages than that obtained on a paper machine, was clearly responsible for the migration of the resin.

Attempts to show up two sidedness in laboratory and commercial papers containing anionic resins by staining with an acid dye (*9*) were not successful. The dye used was Solway Blue B. Cationic resins (*10*) responded much better to staining with acid dyes and showed patterns similar, in a general way, to those obtained with the autoradiograph.

To examine the effect in more detail 120-gram sheets containing 10% added resin solids were made, couched on blotters and dried with the wire side against the hot cylinder.

It was expected that the excessive resin addition and the heavy sheets would produce exaggerated migration effects. These sheets were exposed against Ilford Industrial "B" x-ray film for 30 days. (By this time the activity of the

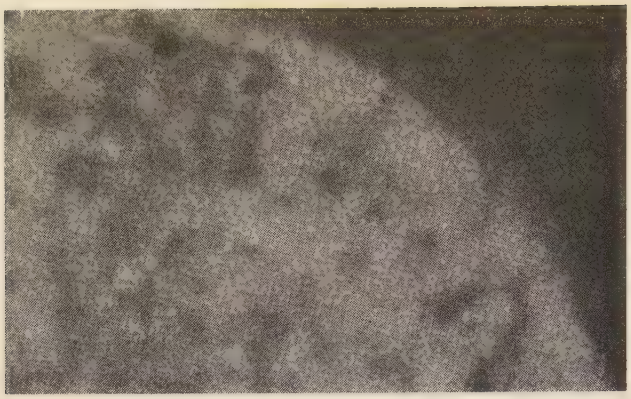

Fig. 1

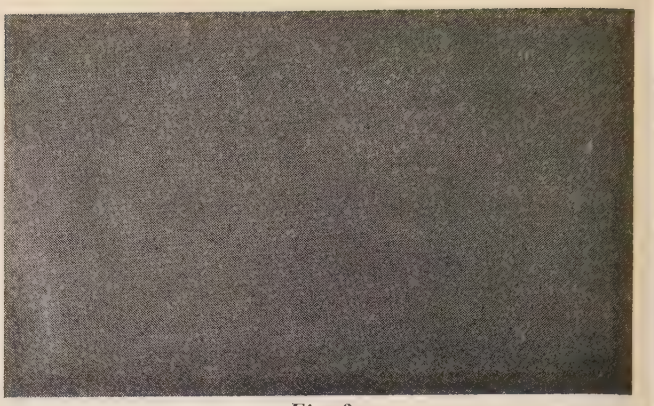

Fig. 3

sulphur in the resin had fallen to 0.46 mc. per gram of sulphur.) Figures 1 and 2 show the autoradiographs for the top and wire sides of a bleached sulphite sheet hot dried on the cylinder. Figures 3 and 4 show the top and wire sides of a sheet dried on rings according to the standard method (*11*). Figure 5 is an enlargement of a portion of Fig. 2. This enlargement shows how the resin has concentrated at the edge of the sheet and also how it tends to concentrate on individual fibers.

Two cylinder-dried sheets were washed thoroughly in water before exposure but the autoradiographs from them showed just as much two sidedness as the unwashed sheets. This indicates that the sulphur is insoluble and is present in the cured resin. If sodium formaldehyde bisulphite had been produced during curing it would have dissolved out when the sheets were washed.

Ten per cent resin solids is a large addition and some of the sheets tended to stick to the drying cylinder and pluck. The patterns produced by this effect corresponded to the autoradiographs. The plucking appeared to be due to the extra concentration of resin along certain fibers.

To test the effect of migration on wet strength double sheets of 120 grams per sq. m. were made by pressing together two 60-gram sheets. The 60-gram sheets were first pressed between blotters for 5 min. and then pressed with the top sides together for a further 2 min. The 120-gram double sheets were then cylinder dried while in contact with one blotter.

Some other double sheets were cold dried on stainless plates. These were made by pressing half the necessary 60-gram sheets against plates according to the standard method (*11*) for 5 min. and then pressing them for 2 min. against 60-gram sheets which had previously been pressed for 5 min. between blotters.

After drying the sheets could easily be split, without damage, into their original components. They were all cured for 10 min. at 127°C. and tested for tensile strength under wet and dry conditions with the results given in Table II.

DISCUSSION OF RESULTS

It has been shown by Best-Gordon (*12*) that urea formaldehyde resins applied for anticrease purposes to cotton and spun viscose migrate sufficiently to give irregular results under uneven drying conditions. To avoid migration, drying on a stenter is necessary and cylinders must not be used. These anticrease resins are applied from solution and may remain in solution until the water is dried off. They are lower in degree of polymerization than the wet-strength paper resins which are adsorbed onto fibers from dilute solution and must, therefore, have a direct substantive affinity for the fiber under the conditions of use.

Preston and Chen (*13*) have studied the movement of moisture and of non-substantive dyestuffs in felt, paper, and cloth and have shown that the solute moves towards the point of evaporation while the steam moves away from it. In cylinder drying the steam moves through the paper away from the cylinder and the water moves back towards the surface nearest the cylinder. In the early stages of heat transfer a kind of "micro-Soxhlet" extraction takes place and solute is rapidly carried towards the points of evaporation near the hot surface. Preston and Bennett (*14*) have shown that migration can occur even with cold drying at room temperature, if there is anything to make the drying uneven. A certain critical moisture content is necessary before migration can begin but they have shown that migration can be caused, even in air dry cloth by putting a hot brass weight onto cloth supported on cold plate glass. The moisture which initially diffuses towards the cold side is sufficient to cause migration as it moves slowly backwards while the cloth comes to equilibrium again.

To be retained at all in laboratory-made sheets a resin must be highly substantive to the fiber. The particular anionic resin used here is substantive to kraft fibers in the presence of alum. The resin is adsorbed onto the fiber and

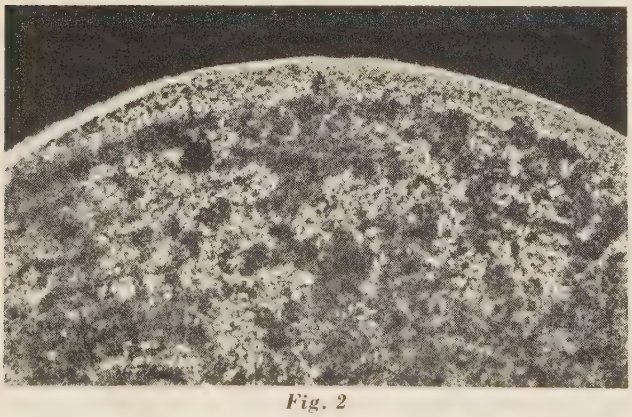

Fig. 2

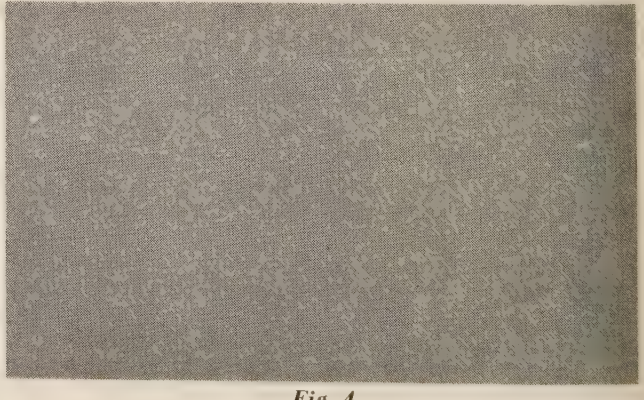

Fig. 4

Table II. Comparison of Hot and Cold Drying on Sheets Which Were Split Before Testing

Pulp beaten to about 430° C.F. in each case

Pulp and resin		*Hot dried* — *Next to cylinder*	*Hot dried* — *Next to blotter*	*Cold dried* — *Next to plate*	*Cold dried* — *Exposed to air*
2.5% anionic urea resin on unbleached kraft	Breaking length, km.	11.15	11.0	12.25	12.3
	Wet breaking length, km.	3.40	2.98	3.54	3.61
	Wet/dry, %	30.5	27.1	28.9	29.3
	Apparent N retention	58	35	45	46
2.5% cationic urea resin on bleached sulphite (*1*)	Breaking length, km.	6.8	7.0	8.2	8.1
	Wet breaking length, km.	2.48	2.51	3.17	3.09
	Wet/dry, %	36.5	35.9	38.7	38.2
	Apparent N retention	45	31	40	40
2.5% cationic urea resin on bleached sulphite (*2*)	Breaking length, km.	6.7	6.6	7.9	7.8
	Wet breaking length, km.	1.79	1.59	2.87	2.9
	Wet/dry, %	26.7	24.1	36.3	37.2
	Apparent N retention	41	30	36	36
2.5% melamine resin added as acid colloid to bleached sulphite	Breaking length, km.	7.35	7.4	8.13	8.66
	Wet breaking length, km.	2.35	2.28	2.68	2.72
	Wet/dry, %	32.0	30.8	33.0	31.4
	Apparent N retention	63	61	62	62

one might expect it to be firmly bonded. At room temperature this is so and there is little or no migration when paper is dried cold. If it is dried hot, however, the urea resins tested by the authors migrate. The difference between hot and cold drying is clearly shown by Table II. It is evident that when the sheet is heated in the early stages of drying much of the urea resin present must go back into solution. It is also evident from Table II that melamine resin, added as acid colloid, does not migrate to any marked extent.

Although these conditions were particularly chosen to exaggerate migration effects the tensile test figures in Table II do not show very much change which can be attributed to migration. The changes in nitrogen retention are much greater than the changes in wet-tensile strength.

With an ordinary paper machine, heating the paper alternately on the two sides one would not expect very much migration but it is possible that it occurs with thick boards. Boards usually give a poorer wet strength than paper and this has been ascribed to hydrolysis of the resins during drying. It might, however, be due to migration. It might, therefore, be worth while to examine the effects of temperature variations on the first few cylinders when trying to get the best result out of a urea resin on a machine using large quantities of it.

With M.G. cylinders papers containing urea resin have occasionally given trouble due to plucking. Our autoradiographs on sheets dried in such a way as to exaggerate this effect have shown that the sticking is due to local concentration of resin.

According to Preston's theory of heat transfer there is repeated evaporation and condensation of water. The rapid movement of water through the sheet may be sufficient to disturb the inter-fiber bonds and this may explain why hot dried sheets are lower in strength than those dried at room temperature.

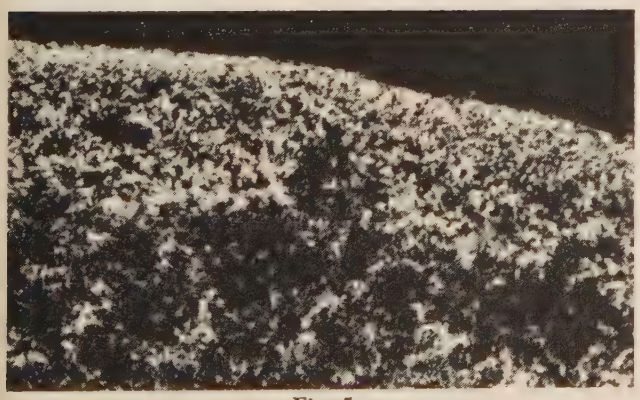

Fig. 5

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Acknowledgment is made to the directors of B.I.P. Chemicals Limited and to the director of the Atomic Energy Research Establishment, Harwell, for permission to give this paper and also to Prof. H. W. Melville for permission to use the Geiger counter in the Chemistry Department of the University of Birmingham.

Evaluation of Rag Papers for Security Printing and Similar Uses

K. E. C. Buyn

To EVALUATE a special type of paper means are necessary to determine the value of that type of paper for its special purpose. Security papers bear a design, the printing of which demands the highest technical performance of the printer's art.

The purpose of security printing is to produce a paper sufficiently substantial and permanent to withstand the wear and tear of normal use, printed in such a way that it presents itself as a paper of high value, leaving no doubt as to its authenticity. The same requirements must hold after long periods of storage under lock and key and after more or less intensive use. The requirements mentioned will, for the purpose of this discussion, be brought under three heads:

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(1) permanence in storage, (2) stability in use, (3) suitability for first-class printing.

PERMANENCE

Permanence is the ability to resist the ravages of time, apart from wear due to handling (shares, loans, legal documents, certificates etc.). The general specifications for this purpose are well known, namely: high initial strength, endurance to withstand folding, and low filler content, always assuming that high *initial* strength should guarantee long life.

The more modern conception, however, is based on the *maintenance* of prolonged strength and the appearance of the securities. Therefore, the fibers in the paper should not be open to adverse influence from outside, while the paper itself should not, of course, contain any detrimental elements (low acidity, no oxidizing agents). Whole, unattacked, fibers make for durability; every injury means a vulnerable spot.

Since fibrillation involves damage to the fiber structure the degree of beating is of primary importance in attaining maximum durability. The replacement of the fibrils by a binding agent which is less vulnerable will increase the length of life. Good results may be expected from the use of melamine and urea-formaldehyde resins.

Although wet strength is not significant where durable papers are concerned, the presence of this quality, however, indicates that the fiber bonds are not very sensitive to water. A general estimate of permanence can be obtained from the effect of accelerated aging (72 hr. at 100°) on folding endurance and the so-called "copper number."

Tub-sizing with gelatin gives a slight improvement in strength and some protection against adverse atmospheric influences, especially through the hardening effect of the gelatin. Other protective layers should also be considered.

STABILITY IN USE

Papers which are intended for intensive use and handling must be able to withstand abrasive wear without becoming flabby, e.g., military maps, identity cards, passports, driving licences, traveler's checks, as well as banknotes and similar currency papers.

The normal strength requirements apply here and also those of hardness and stiffness of the paper while liability to attack from outside factors is also important.

Mechanical abrasion by folding, crumpling, and wear, especially on the edges of the folds, can be observed in the relative decrease in strength. To this end special instruments have been devised.

A certain durability and, if possible, closeness of texture are required to prevent deteriorative agents, particularly those which tend to attack the fiber bonds, from penetrating and thus soiling or weakening the paper. Of these water is of foremost importance, also because of the many noxious elements which may be dissolved in it.

The internal binding of the fibers is very important. The strength in a wet condition gives an indication of the stability of the fiber binding in general and particularly in water.

Wet strength is usually measured by means of a tensile strength tester and observation of the bursting strength. For the papers under consideration, however, surface wear is at least as important as wet strength.

Many instruments are available for the study of abrasive wear. The majority use emery paper which affects the paper surface unequally. Cloudy papers, in particular, show localized weak spots. Emery and similar abrasive materials are indeed extremely damaging to paper in a wet condition; testing with the rubber eraser or with the brush will for that reason be more suitable.

Very good results have been obtained by the use of a revolving brush.

The paper was immersed in water for 5 min., which time was considered sufficient for the immersion to be fully effective. The advantage of brushing wet paper is that the surface is worn down, exposing the inner layers to the water. If, at intervals, water is dripped on to the paper, the cellulose fibers will swell and soon become loose, while the sizing agents, melamine for example, are able to withstand the water.

Thus, additional information concerning the paper structure may be obtained, which could not be derived from the bursting strength, namely the answer to the question whether the resistance to water is a result of a protective coating on the paper surface, or of the strength of the internal fiber bonds.

From the combined effects of crumpling and brushing additional information can be obtained on the protection provided by thin coatings on the paper surface under adverse conditions.

Table I

	Weight, g./sq. m.	*Double folds (mean)*	*Tensile strength (mean)*		*Bursting strength*		*Brush resistance, revol.*	
			Kg.	*M.*	*Dry*	*Wet*	*Wet*	*Water added*
Loan paper G	70	1500	6.1	5500	2.4	0.4	12	12
Wet-strength rag paper U	65	1700	7.0	7000	3.0	1.2	220	190
Common loan paper HW	90	3500	9.0	6500	3.6	0.3	10	10
Wet-strength rag paper PB	90	3200	9.3	7000	4.1	1.3	230	230
Super tub-sized A	80	3300	7.4	6400	...	...	250	200
Hard sized, wet-strength rag paper B	90	9500	11.2	8000	...	...	1200	1200

Table II

	Brush resistance	
	Wet	*Water added*
Common loan paper, tub-sized, 90 g./sq. m.	10	10
With cellulose acetate, coating	>500	105
Same, crumpled	53	28
With plastic layer	450	375
Same, crumpled	420	325

Of course, the brush test is also a rather arbitrary one. From the tables, however, it is apparent that the results with various types of paper give a workable general information which may be used in conjunction with data obtained by other methods.

SUITABILITY

The suitability of the sheet for use in various types of printing presses and the behavior of printing ink on the paper, are a problem which draws our attention in daily practice. To be considered are the many well known troubles resulting from loose fibers, curling edges and variations in size, due to insufficient control of atmospheric conditions, etc. Ink-absorption is also important and drying, with its twin prob-

lems of strike-through and offsetting. Lesser known problems are those of tub-sized papers refusing the ink and causing it to emulsify in the water feed, and slow drying due to an excess of formaldehyde.

PRINTABILITY

The aptitude of the paper to accept a print is of equal importance in security printing. The image has to be transferred on to the paper in a fraction of a second, often under enormous pressure, and yet the print must be clear and defined.

In our study of the requirements of security papers it is of the utmost importance to know which qualities in the paper make for printability, qualities which must be measurable by instruments.

These qualities will not, as a matter of fact, necessarily coincide with requirements of durability and permanence, on the contrary, it is well known that soft and smooth papers—that is compressible papers with a smooth surface—give a better result in printing. Moreover the paper should be sufficiently porous to allow the air to escape from between the form or plate and the paper.

This applied equally to letterpress and intaglio printing. Practice shows that these factors alone are not sufficient. The form must be able to make some impression into the surface in order to obtain a sharp print; the fiber structure of the surface tends to offer resistance. Microscopic studies show that the sharpness of the printed lines are affected to a great extent by the structure of the surface.

This is not surprising when one compares the size of the particles and the cavities in between, to that of the component parts of the printing surface (dots, lines). The breadth of small characters in letterpress and offset lies between 60 and 200 mu while the dots themselves are 20 to 30 mu in diameter. In gravure plates the measurements are even finer, ranging from 20 to 100 mu, while the depth of the engraved lines is often less than 10 mu. In general, the surface of security papers is rather hard and not very smooth. At the moment of impression the surface of the block or plate first comes into contact with the thicker fibers which form the highest points of the paper surface. These fibers force the ink aside and towards the cavities between them. The coarser the paper surface the greater the extent to which the print is fractured by the fibers and to which the edges of the lines become fuzzy ("feathering"). It has been found that coating is not sufficient to level the surface with the protruding fibers. The thinner and softer the fibers the better the result in printing. The filling up of the pores in the paper surface with small fibers or with fillers gives some improvement in printing but these practices do not exactly improve the strength of the paper. Fibrillation must also be limited since the fibrils themselves do not give a smooth surface due to considerable swelling and shrinkage.

Covering with a layer of synthetic coating has been recommended in order to obtain a really smooth surface, but this requires a layer of such a thickness as to render the paper unsuitable because of the excessive smoothness of such a layer and its sealing of the pores.

EVALUATION

The evaluation of security papers and the drawing up of specifications for its manufacture is not an easy task. In principle, there is not much divergence between the requirements for permanence and durability in daily use; these must be weighed against the often conflicting interests of good printability. Sometimes one must also take into consideration its suitability for writing and erasure.

In the manufacture of security papers cooperation is required from both the papermaker and the printer, who can adapt his part of the work by such methods as conditioning of the paper; using rubber instead of metal for blocks; altering, among other things, the wiping system on the gravure press.

The directions and specifications of the client must also be taken into account when evaluating these conflicting requirements. One must consider, for instance, whether durability in use is so important as to warrant a relatively high cost; or whether security demands such a high quality of printing as to sacrifice, to a certain extent, the length of life. One must also take into consideration whether the accuracy in printing and small discrepancies in size are of vital importance in practice, while in the sale of security papers price considerations play an important part.

All these observations stand or fall upon the possibility of accurately measuring the qualities required. For paper research a number of good instruments are available, and others can be constructed for special purposes.

The evaluation of the readings from these instruments depends upon our knowledge of their relation to the specified requirements and, last but by no means least, upon the relation of the requirements and the tests to paper manufacture: that is the relation to the methods of control in production in order to achieve and maintain the various qualities; the control and the effective variation of raw materials, beating, mixing, sizing; the running of the machine; drying, etc. so as to produce the kind of paper required.

The evaluation of security papers demands a skilful handling of the main factors which apply when using gages and their correlation in manufacture. This evaluation is in a state of development. We hope that in the near future the knowledge of paper composition and structure will enable us to prescribe the requirements for the manufacture of suitable printing papers.

Presented at the meeting of the TAPPI Overseas Discussion Group held in Paris, France, May 20–21, 1955.

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ALBERT AWARD PAPERS

Delaware Valley Section, Philadelphia, Pa., May 26, 1955

Correction of Color Two-Sidedness at the Size Press

PHILIP A. CERASOLI

THE phenomenon of two-sidedness in paper, in some form or other, has plagued the papermaker since the first paper machine. And with the higher production goals now prevalent, it appears as if the situation is tending to become even more acute.

Undoubtedly, new production techniques are in order if two-sidedness is to be kept to a minimum. It is the object of this paper to present one such technique wherein a form of two-sidedness is minimized. But before entering into the main theme of discussion, correcting color two-sidedness at the size press, it might prove beneficial if some thoughts were advanced regarding the aspects of two-sidedness in general.

TWO-SIDEDNESS

Basically, two-sidedness could be subdivided into two all-encompassing classifications: structural and color. Structural two-sidedness results from the heterogeneous dispersal of filler and fiber from the top to the bottom of the sheet. Color two-sidedness, on the other hand, is the variation or difference in color shade and/or depth which exists between the felt and wire side of a colored sheet.

Structural Two-Sidedness

Focusing attention on structural two-sidedness, one finds that it is more or less common knowledge that the felt side of a sheet is proportionately richer in "fines" and filler than the wire side. The reasons for this condition have served and will continue to serve as the objective of innumerable studies. Nevertheless, some of the agents responsible for the uneven dispersal of "fines" and filler are understood by almost everyone intimately associated with the mechanics of papermaking.

From the slice opening to the first drier, the web is under the strongest of those influences which create and accentuate structural two-sidedness. The cumulative effect of the table rolls, suction boxes, and suction couch on water drainage of the web on the wire contributes markedly to structural two-sidedness. This implies that there are other factors such as press conditions and drying action which help to bring about structural two-sidedness. It seems that, in the main, those steps taken on the paper machine directed to the removal of water also create structural two-sidedness.

Color Two-Sidedness

Color two-sidedness could be considered, from a point of view, as structural two-sidedness in technicolor. In other words, color two-sidedness is, in many instances, an effect of structural two-sidedness, for, if structural two-sidedness was to be reduced or eliminated, a great improvement in color two-sidedness would also result. The proportionately greater amount of "fines" and filler on the felt side with the increased surface area they afford tend to absorb more of the dyestuff. This would probably produce a sheet deeper in color on the felt side than the wire side. However, the wide range of dyestuffs available allows for a certain degree of maneuverability in reducing color two-sidedness. Dyestuffs preferential to filler, while others with a greater affinity for fiber, and still others less susceptible to pH changes and drying conditions can be purchased.

This type of attack is limited, though, by the final color desired, the overall conditions of operation, and the cost involved. There is a mechanical approach to the correction of color two-sidedness, however, which has proved successful. The ensuing discussion will attempt to explain the development of a mechanical system for the correction of color two-sidedness.

MECHANICAL CORRECTION OF COLOR TWO-SIDEDNESS

Approximately 2 years ago, W. C. Hamilton & Sons undertook the correction of color two-sidedness by utilizing a staining system at the surface-size tub. In essence, the system was so devised that colored size could be applied to the wire side simultaneous with the feeding of uncolored size to the felt side. The first installation consisted of a dyesuff dissolving and feed tank, an applicator tray something on the order of a waterbox at a calender stack, a color proportioning pump, a surface-size flow regulator, and a colored-size mixing and feed tank.

To operate this first installation, Fig. 1, the necessary dyestuff or dyestuffs were dissolved in the stainless steel dissolving feed tank. The dissolved dyestuff was then proportioned with a Lapp pulsameter into the colored-size holding and feeding tank simultaneously with uncolored surface-size which was being drawn from the machines' regular supply tank at a specific rate with a Kates flow regulator. The colored size was then continuously pumped into the applicator tray which was positioned against the lower size-press roll.

The lower press roll "picked up" the colored size and carried it up to the wire side of the sheet. The overflow from the applicator tray was caught into the machines' size tub and sent back to the colored-size holding tank from which it recirculated back to the tray. In the meanwhile, uncolored size was applied with a system of showers to the felt side. The excess uncolored size overflowed the edges of the sheet and into the machines' size tub. Incidentally, the make-up of the colored-size was done automatically and continuously. The level in the colored-size mixing-holding tank was controlled with a liquid level controller which activated the Kates flow regulator feeding the uncolored size and the Lapp pulsameter proportioning the dissolved dyestuff.

This primary installation presented numerous difficulties, some large and some small. After two or three trials, however, it became apparent that one serious problem existed which had to be eliminated. This problem centered about the overflow of the uncolored size from the felt side into the machines' size tub. Previous mention was made to the overflow into the machines' size tub of the colored size. Both the excess uncolored and colored size flows were being caught into the machines' size tub. Obviously, this was a weak point for the uncolored size was diluting the strength of the colored-size. Though intentions were to rigidly control the overflow of the uncolored size by regulating the showers so that just enough uncolored size was supplied, it was discovered that

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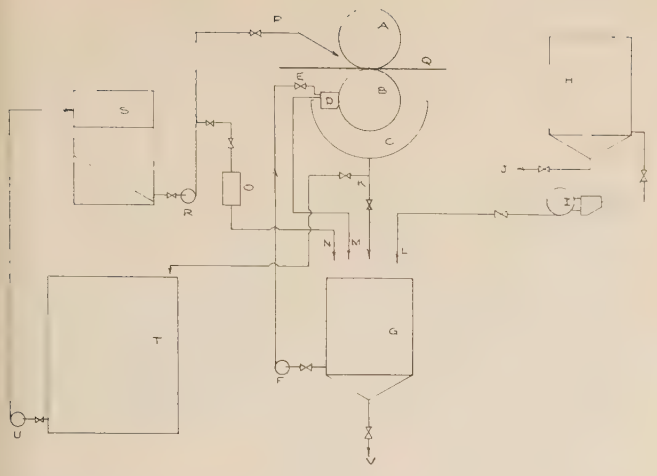

Fig. 1

A—Upper size-press roll. B—Lower size-press roll. C—Size tub. D—Applicator tray. E—Colored-size inlet. F—Colored-size pump. G—Colored-size mixing-feeding tank. H—Dyestuff dissolving tank. I—Lapp pulsameter. J—To sewer. K—Overflow lines. L—Inlet to colored-size makeup tank. M—Overflow to colored-size makeup tank. N—Uncolored size inlet to colored-size makeup tank. O—Kates regulator. P—Uncolored size feed to wire side. Q—Paper. R—U—Uncolored size pumps. S—Uncolored size screen. T—Uncolored size feeding tank. V—To sewer.

this was difficult to accomplish because of the surges in the pumping system. At one moment there would be just enough uncolored size and at the next moment there would not be enough. Further studies showed that there was no choice but to separate both systems completely and develop the installation so that it would require little attention.

Improvements over First Installation

The first step in this improvement program had as its objective the elimination of the colored size into the machine size tub which was serving as the catch-all for both sizes. To accomplish this separation it was decided to seal both ends of the applicator tray and locate an overflow line, feeding back to the supply source, in the center of the tray. Because of the various sheet widths run, the sealing devices had to be movable so that they could be placed anywhere on the tray but within 8 in. from the edges of the sheet. The first sealing dams were fabricated from wood blocks approximately $2^1/_2$ in. wide and as high and wide as the applicator tray. The upper side, the front edge curved to fit the shape of the press roll, and the bottom front of the blocks were lined with felt about $^3/_4$ in. thick. When clamped on the tray and pressed up against the press roll, the blocks (at both ends), with their felt linings, served as effective dams. Nothing was done to change the felt side, or uncolored-size, system.

The first trial using the seal-in colored size technique was not entirely successful. In the first place, the overflow had been placed too close to the inlet. The colored-size entering into the tray through the inlet went almost immediately down the overflow line. This made it difficult to build up the amount of size needed to rise above the height of the rubber lip of the applicator tray. The overflow outlet was subsequently changed and positioned at the opposite end of the tray away from the inlet side where it has since worked very successfully. The other discovery made during this first trial was that the colored-size, when carried up by the bottom press roll, fanned out over the dams and into the uncolored size. This situation was a reversal of the original problem of uncolored size flowing into colored-size. Obviously, nothing would be gained unless this was rectified. To correct this, air jets were located at both ends of the size tub and so aimed to blow the overflow of colored size back into the confines of the tray. Subsequent trials proved this arrangement, except that considerable time had to be taken during each run to set up the air jets and regulate the air flow. Too great a force of air would blow too much of the colored-size away with the result that the 2 or 3 in. of the wire side of the sheet would go unsized. It was also noted during these trials that the method of sealing the ends of the applicator tray was far from perfect, since considerable amounts of colored-size were leaking into the uncolored size. There was no doubt that further improvements had to be made.

Final Improvements

To begin with, air jets which could be aimed in any direction or angle were permanently installed. All that needs be done now to operate the air jets is to turn on the air supply and aim the air stream.

To eliminate leakage at the dams, two dams are located at each end with an overflow outlet between each dam. Thus what escapes the first dam is trapped by the second or extreme end dam. Trials indicate that with the two dams at each end it might be possible to eventually eliminate the air jets.

An attempt has been made to explain the development of a method of correcting color two-sidedness at the size press. The present installation operates very satisfactorily and the colored and uncolored size systems can be considered separate. An improvement of color two-sidedness has been effected allowing for increased production and quality.

An E. J. Albert Award paper presented at a meeting of the Delaware Valley Section of the Technical Association of the Pulp and Paper Industry, Philadelphia, Pa., May 26, 1955.

The Value of the Beta Gage Profiler to Determine Coating Distribution

WALTER R. SMICKLE

THE beta ray profiler has proved an effective and reliable device for rapid and efficient determination of weight levels across a given sheet of paper. Its advantages are at once apparent. The beta profiler gives graphic presentation of the mass distribution across the sheet within a minimum amount of time. Although its mechanism is highly complex, it is extremely simple to operate and requires little training of personnel. From the profile, it is possible to transfer the information on the graph or chart and apply it to make the necessary adjustments for the correction of an unlevel sheet on the paper machine.

The absolute necessity for level rolls in the converting process is obvious. An unlevel roll can result in a floppy sheet and wrinkles on fly rolls and at impression points. In minor cases, friction adjustments and leaders may help but this type of adjustment entails constant readjustment which can lead to costly down time. Therefore, we may conclude that the paper converter can operate his equipment most efficiently when he uses stock of constant characteristics.

In the coating of paper, mass is added to the sheet and consequently the characteristic is altered by the extent and type of coating required by the end use. However, the coating application is rarely the final step in converting paper, and therefore not only is it essential that the base sheet have a favorable weight level profile but also that the coating distribution be uniform, not only to yield level rolls but also to give uniform protective features.

In packaging papers protective qualities naturally must be of high standards to insure against deterioration of the packaged goods. The packaging operation must be efficient and complete if the packaged goods is to reach the consumer in good condition. This is especially true of packaged food products. A great advantage in using coated papers for

WALTER R. SMICKLE, Control Department, Riegel Paper Corp., Milford, N. J.

packaging lies not merely in the fact that it provides a clean and attractive appearance but that it affords an effective heat seal against contamination. The packaging machine operates at a relatively high rate of speed; consequently, the stock involved must be of uniform standards. A light coating area will not give a good heat seal and therefore results in poor packaging features. This can allow contamination and also it is very likely to permit spilling on the packaging machine which will jam the operation and necessitate costly down time for clean up before smooth operation can be resumed.

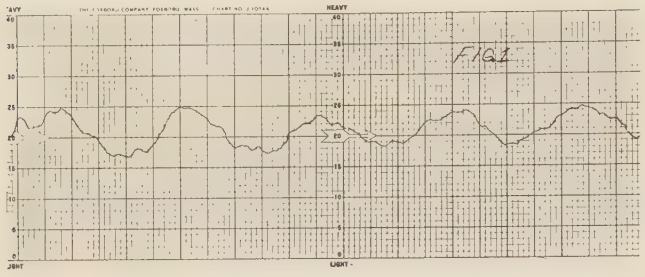

Fig. 1

This paper will treat more specifically the maintenance of uniform coatings as applied on roll-type coating machines, by using the beta gage profile of the coating mass. In roll-type coater, the coating distribution will vary with the impression under which it is applied to the web. The basis weight by extraction run on a single representative sample of the coated web may well indicate the amount of coating in the standard ream of paper to be within specifications but will not tell with any reasonable degree of accuracy the coating distribution on the web.

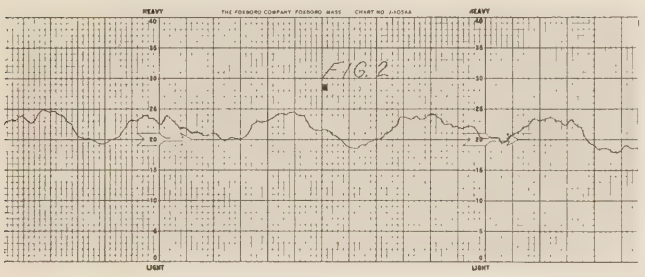

Fig. 2

To determine coating distribution accurately by actual extraction is a tedious and time consuming task not adaptable to routine testing station performance. Samples must be painstakingly prepared to insure that the complete circumference of the coating roll is included and cut to sizes which will not cover too great an area of the coating roll and yet not be small to the extent that they become insignificant. Needless to say, this method of sampling can become highly arbitrary and more and more cumbersome as the size of the coating roll increases. Each individual sample must be accurately labeled and weighed. The coating is then extracted; the samples dried and reweighed. From the weight differences we can give a numerical representation which will indicate the amount of coating on the given samples as applied by specific areas of the coating rolls.

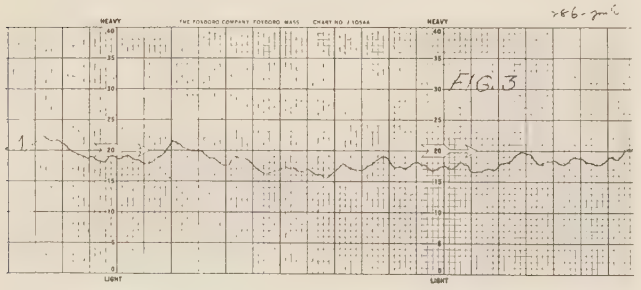

Fig. 3

The use of the beta gage profiler for the same determination makes a tremendous reduction in time and effort and gives a graphic expression of the results. The procedure is amazingly simple and leaves very little for arbitration. From experience with the extraction method it has been determined that the trouble spots or unlevel coating areas tend to arise nearer the front and back edges of the web rather than in the middle. This would indicate that the kiss is most constant near the middle of the web and that fluctuation in impression as a result of wear on the coating rolls or bearings will first cause coating variation nearer the edges of the web. Bearing this fact in mind, it apppears most logical that periodical checks of coating distribution should be made on samples secured from the edges of the coated web, for it is here that any variation will first be evidenced. Naturally samples should be obtained on the greatest deckle possible. These samples marked to identify them as front and back, may include as many revolutions of the coating roll as desired because they are taken in the machine direction. The next step is to perform a beta gage profile in the same manner that cross machine samples are profiled for control on the paper machine. Then the coating is extracted and a

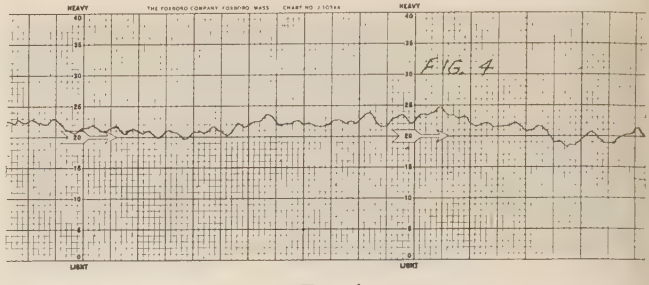

Fig. 4

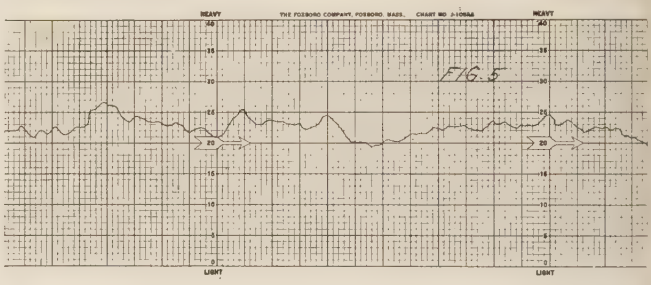

Fig. 5

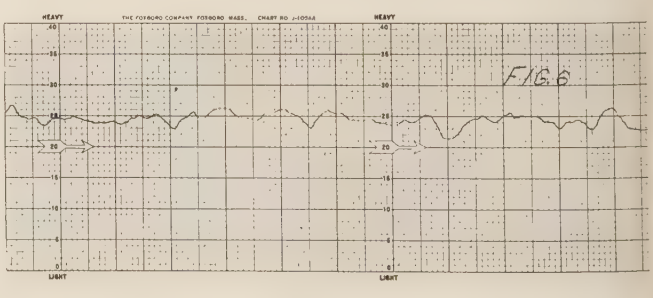

Fig. 6

profile performed on the base sheet from which the coating has been removed. By visual comparison of before and after coating profiles, we can determine the condition of the coating rolls at a glance. If the profiles indicate that the coating rolls might be faulty, a recheck may be performed in a matter of minutes and corrective measures taken.

The attached charts are reproductions of an actual condition found to exist in defective coating rolls. Figure 1 represents the profile for the front of the coated web of suspected unlevel coating. Figure 2 represents the back edge of the same web. Figures 3 and 4 represent the same samples after the coating was extracted. The more favorable profile pictured on the base paper in Figs. 3 and 4 would indicate the coating rolls are in a faulty condition. In the case cited here, comparisons were made by using the extraction method to determine the significance of the fluctuation registered in the profile graph. The coating weight variation indicated by the profile was found to have a difference of 4.3 lb. from the light to the heavy areas. This great a variation is, of course, highly significant with respect to heat seal and can give rise to trouble in the converting process as well as in the end use. Figures 5 and 6 represent the profiles of coated samples, front and back respectively, on which the coating was applied by new rolls which replaced the suspected defective rolls.

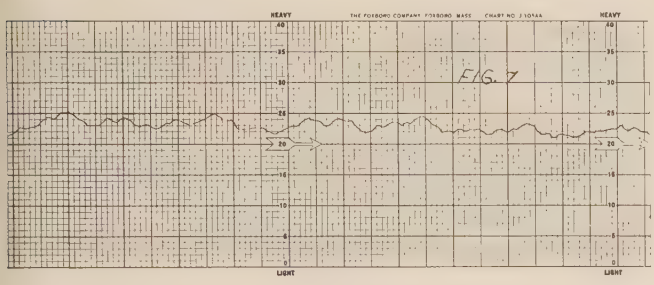

Fig. 7

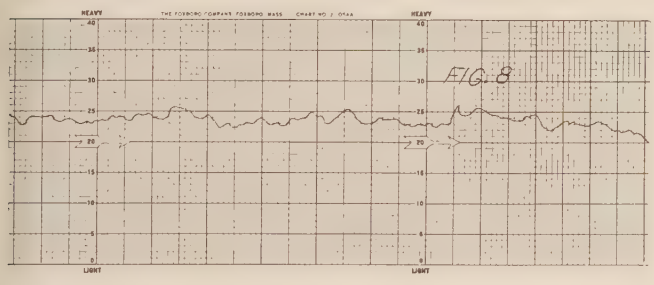

Fig. 8

Figures 7 and 8 represent the profiles of the base paper in Figs. 5 and 6 after the coating was extracted. The obvious more favorable comparison of Figs. 5 and 6 to Figs. 7 and 8 substantiates the fact that the rolls used in coating the samples under Figs. 1 and 2 were defective and applying the coating unevenly.

In a very short period of time and with a minimum effort the use of the beta gage profiler has enabled us to accurately determine the condition of the coating rolls and thus avoid costly waste of time and material. The information obtained from this experiment can be used for future comparisons and make it possible to follow the pattern of the coating roll surface so that maximum life of the rolls is obtained without danger of producing an unlevel coating.

An E. J. Albert Award paper presented at a meeting of the Delaware Valley Section of the Technical Association of the Pulp and Paper Industry, Philadelphia, Pa., May 26, 1955.

Organoleptic Quality Control in a Specialty Paper Mill

BRUCE H. SCHRIER

In the years following World War II, the flexible packaging industry has experienced a great increase in activity due to the following trends:

1. The widespread changeover from rigid containers to flexible packaging in the food, hardware, drug and cosmetic industries.
2. The development of new products such as instant beverages, frozen and dehydrated dinners, powdered milk products, and oven-ready baked goods.
3. The increased sale of convenience to the customer in the form of premeasured or unit packaging, prepared foods, ready-cut meats, pastry mixes, and the like.

One result of these trends has been to put on the grocer's shelf products which are either very sensitive to odor contamination or products which possess a strong odor themselves.

To offer the increased level of protection demanded for the wide variety of delicate and sensitive food products, the structure of the packaging web has become more complex. Materials are being used which can become sources of odor contamination, and the problem is complicated by increased production speeds necessary to satisfy the ever-expanding market.

The work described in this paper was initiated when a shipment of polyethylene resin was received which exhibited a definite off-odor. The packaging laboratory, in view of their experience with the effect of long-term storage on the palatability of foods products, was requested to develop a test for odor level which could be used for quality control purposes.

Methods of odor analysis described by the literature were found to be, in general, too time-consuming and cumbersome for control purposes, although their usefulness in research and appraisal went unquestioned. The use of glass jars to accumulate an odor, as suggested in the TAPPI methods, seemed the most promising by virtue of its simplicity (*1*, *2*). After 3 months of investigation, a method was proposed which can be outlined as follows: (1) a given weight or area of the material to be tested is placed in an odor-free glass jar and sealed in the jar with aluminum foil, (2) the development of odor is accelerated by heating the jar and its contents, (3) the jar is brought to room temperature and evaluated according to an arbitrary scale of values.

Odor-free glass jars are prepared as prescribed by Crocker (*3*). They are scrubbed with a nylon brush in hot water and detergent, rinsed in water at 160 to 180°F., dried for 1 hr. at 220°F. in an odor-free oven, and promptly sealed with 1-mil aluminum foil and rubber bands. The foil is baked to remove odors.

Using this method, it has been possible to evaluate the odor level of packaging materials with a minimum of time and equipment. The test takes less than 5 min. of the operator's time once a stock of odor-free jars has been prepared.

The following examples will illustrate the simplicity and flexibility of this method for preparing samples for odor evaluation. Unless otherwise stated, the conditions of acceleration are 1 hr. at 120°F. a temperature chosen as being within the range of temperatures experienced by materials under common shipping and storage conditions.

1. *Packaging webs* at a given stage of processing are sampled by cutting a lap from the roll at least three sheets in thickness, taking care not to expose the inner sheets to the atmosphere. Leaving the lap intact, 3 by 6-in. sheets are cut in a random manner across the width of the sample, using a razor and template. The top and bottom sheets are discarded; the inner sheets are crumpled one by one, placed in

Bruce H. Schrier, Riegel Paper Corp., Milford, N. J.

an odor-free jar, and sealed with foil and a rubber band. Crumpling is done to expose as much surface as possible to the air in the jar. Our quality control work is based on the odor developed from 1 sq. ft., or eight 3 by 6-in. sheets, of material in each jar; this quantity was chosen to approximate the area of paper used in common packages.

2. *Polyethylene resin* is tested by placing approximately 200 grams of a representative sample of the pellets in each jar. This rather large amount is used for screening tests only; trial extrusions of resins which pass the first test are evaluated as in method 1. It has been our experience that oxidation is the chief source of odor in polyethylene resin, and 200 grams of resin are tested to detect traces of oxidized paraffins which may lead to more severe odors during the high temperatures of extrusion.

3. *Inks, adhesives, and coatings* are evaluated by making drawdown coatings on odor-free paper with a no. 3 Mayer wire. Depending on the material, the coating is dried in a standard manner and tested according to method 1.

4. *Roll wrappers* and associated materials which come in intimate contact with a critical paper are evaluated both wet and dry. To one of a duplicate set of jars prepared as in method 1, 50 ml. of distilled odor-free water are added to simulate adverse storage conditions.

5. *The odor permeability* rate of a given web in package form is tested by making up a package, placing in it an odorous material such as naphthalene crystals, sealing the package, and placing it in a sealed odor-free jar. The jar is stored at a given temperature and opened periodically to determine the point at which odor can first be detected. The design of the test package simulates the construction used by the customer.

6. *Processed water* and other liquids are evaluated after both 1 and 16-hr. storage periods in the jars at room temperature.

It is most important to observe all precautions against contamination of the sample and the jars during sampling and sample preparation. Each jar is sniffed prior to placing a sample in it; the hands, tools, oven, and atmosphere must be free of detectable odor. Testing at Riegel is conducted some distance away from the actual converting operation.

Equally important are the screening and training of the testers (*3*). A triangular test, involving two identical samples and one slightly different sample, was used for initial screening of personnel and is used as a panel check before attempting a critical analysis. A period of training has been initiated to help the tester become familiar with the odor types most frequently encountered.

Odor fatigue is a constant danger; tests are limited at present to no more than five samples before taking a 10-min. rest. Panel members are chosen from personnel who are not subjected to the mill atmosphere for long periods of time.

Actual testing is done under conditions as ideal as is feasible in a paper mill. Testers who smoke refrain from smoking for 20 min. before an evaluation; mouth-rinsing is used, and the hands are kept away from the jars during testing. The use of perfumes and other cosmetics is discouraged.

The scale of evaluation presently in use is an adaptation of a scale previously used for evaluating the flavor of food products. It combines an estimation of quantity of the odor with a description of the basic odor types. The table of seven values, from odorless to what may be termed a "definite, objectional" odor, makes distinctions which untrained personnel are unable to detect. However, any arbitrary rating scale may be used with the method, such as that recommended in the suggested TAPPI method (*1*).

The jar test has proven very helpful at Riegel both in control and research. Its investigation has led us to several conclusions, one of which is that it is much easier to use odor-free raw materials than to attempt to remove the odor from materials which may well be satisfactory in other respects. An investigation of the effect of heat on the odor level of certain inks, for instance, has shown that while solvent odors are easily removed on heating, odors emanating from resin binders are not substantially reduced after 2 hr. heating at 140°F.

The terms "odorless" and "odor-free" as used in this paper are defined in terms of the "threshold value" of a given odor, and are not to be interpreted literally. The threshold value of an odor may be defined as that concentration of an odor in air below which the odor cannot be detected. This value can vary between observers or with the same observer under changing conditions. Turk has proposed that odor concentrations below the threshold value can exert a measurable effect on the human animal (*4*) and it follows that the only absolute test of the odor characteristics of a packaging material is the result of product storage tests as interpreted by a statistically significant number of testers.

It is the writer's opinion that the production of odor-free packaging materials is best accomplished by obtaining odor-free raw materials, converting them under conditions which will avoid contamination of the web and protecting the finished product from contamination during transit and storage. Intensive quality control is necessary every step of the way, and it is hoped that the work discussed in this paper will invite further investigation of the problem.

LITERATURE CITED

1. TAPPI Standard T483 Sm-53—"Odor of Packaging Materials."
2. TAPPI Routine Control Methods RC-208—"Odor of Treated Papers—Jar Method."
3. Crocker, Ernest C., *Tappi* 35, No. 9: 169A–175A (Sept. 1952).
4. Turk, Amos, "Symposium on Odor," A.S.T.M. Special Technical Publication No. 164, page 9.

An E. J. Albert Award paper presented at a meeting of the Delaware Valley Section of the Technical Association of Pulp and Paper Industry, Philadelphia, Pa., May 26, 1955.

Evaluation of Paper Mill Biocides

GEORGE HUNT

The evaluation of biocides for paper mill utilization has for some time posed a problem. Normally, previous to a mill trial, the majority of the work is carried out in test tubes, flasks, petri dishes, and other equally useful cultivating containers. Results of such experiments, reliable as they may be, are often questioned on the basis that these containers do not simulate conditions at the wet end of a paper machine.

The use of glassware in evaluating biocides has led to suggestions that the walls of the containers are unlike those in the wet end of a paper machine. This is quite correct since the headbox is normally wood, metal, or ceramic material. The surfaces of these materials are somewhat of a contrast to smooth walled glass containers. The fact that an artificial media is used for growth purposes has at times been questioned. Assuming a synthetic media composed of mineral salts and glucose is used, it is difficult to compare this to pulp slurry. Agar without nutrient additions would seem to qualify, in the sense of not introducing "artificial" material but again is unlike the pulp slurry. Maintaining a steady pH is also difficult in small containers. Temperature can be maintained with ease and the approximation of similar aerophilic or microaerophilic conditions may also be readily obtained by not disturbing the culture vessel. This latter again loses similarity to a pulp slurry since in the latter the fibers remain in suspension.

We have what we consider to be a logical answer to such inquiries. This is a wooden tank 12 ft. long and 3 ft. wide. The tank is divided longitudinally by a middle fin and each of the two longitudinal compartments is further subdivided

George Hunt, Scott Paper Co., Chester, Pa.

forming a total of 11 compartments. The flow pattern can be more easily understood by consulting Fig. 1.

A flow pattern of this form was designed to provide dead areas similar to those found in the wet end of a paper machine.

The tank itself is constructed of $1^1/_4$-in. cypress. The inside dimensions of each run are 18 in. across by 18 in. deep with a total flow length of 24 ft. Thus the total volume is

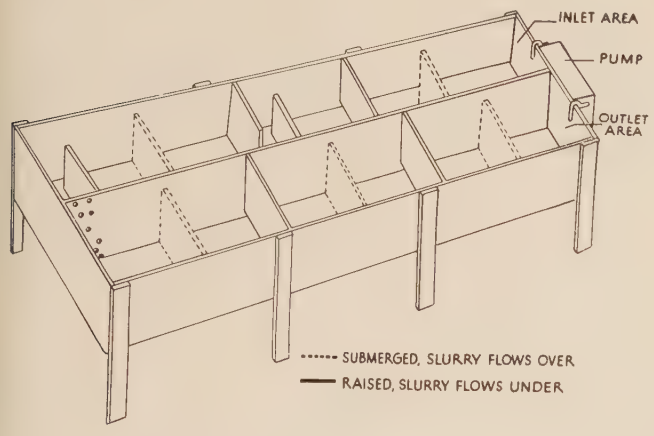

Fig. 1

54 cu. ft. with a capacity of 404 gal. Normally the tank is run at a capacity of 370 gal. which appears adequate. The recirculation time with only the recirculation pump on is 55 min. The time with an overflow rate of 30 gal. per hr. and the recirculating pump working at the previous capacity of 402 gal. per hr. is 52 min. This appears adequate to maintain the fibers in suspension. In using the recirculation pump, it was necessary to install aeration tubes to maintain proper fiber suspension. Water is introduced into the tank in two ways. It may be metered in, or, for wash ups and the like the meter may be bypassed. Both hot and cold water are accessible. A constant feed mechanism consisting of a barrel containing 3% stock and a series of five cups on an endless belt is used to feed the tank. The cups are designed to give a total of 125 ml. of 3% stock per min. This is diluted with 0.5 gal. of water per min. giving a final concentration of 0.18% stock, after equilibrium is reached. The tank is initially charged with 5.6 lb. air-dry pulp giving a concentration of 0.18% stock.

The foremost thought in constructing this tank was for the evaluation of biocidal agents. In this connection it would seem opportune to examine the microbiological aspects of this tank.

One phase which necessarily comes to mind is oxygen tension. The baffles designed as they are provide areas of pulp accumulation, at the same time provide areas of reduced oxygen tension. While the rest of the tank is undergoing active aeration these areas provide a microaerophilic condition to some extent. It is naturally somewhat improbable that anaerobic areas could even be achieved in the present structure but areas of variable oxygen tension do exist. This has provided us with information of which we were previously unaware. Specifically bacteria develop both in these areas of pulp accumulation and also in the more aerobic areas, but fungi and protozoa appear restricted to the areas of pulp accumulation and to the wooden walls of the tank. Also enmeshed or trapped in the pulp-fungi growths on the walls are numerous bacteria. It is extremely rare that fungi or protozoa are represented in a random sample taken from the tank. The most logical explanation for the location of fungi is found when one considers that in order for fungi to exhibit luxuriant growth it is necessary for the fungi to form a mycelial mat and this can most easily be accomplished by the anchoring of the fungi to the fibers of the wall. The protozoa find a comfortable existence in the irregularities of the surface of the wooden walls. It is in these areas of fungi and protozoan growth that small quantities of pulp accumulate and the overall effect is the characteristic slimy feel sometimes found in paper machines.

The temperature of the stock is normally adjusted to a room temperature of between 20 and 25°C. This temperature was chosen because paper machines do not normally operate at 37°C. Naturally, such temperatures are reached in some plants during the Summer months but this is greatly reduced in the winter. It appears that microorganisms rapidly adjust to this temperature and grow adequately after acclimatization. This may easily be an adaptation phenomenon since the majority of bacteria isolated exhibit maximum growth at 37°C. This of course does not include soil bacteria. The water entering the tank with the constant feed system is in many cases colder than 20°C. To overcome or compensate for this an immersion heater has been installed which maintains the temperature at the aforementioned level.

The third factor to be considered is the pH range. It is readily understood that enzymes demonstrate optimal activity at specific pH's depending on the enzyme. In a non-wet strength system no attempt has been made to adjust the pH and it is normally around pH 7.0. This does not appear adverse to the development of any of the organisms present.

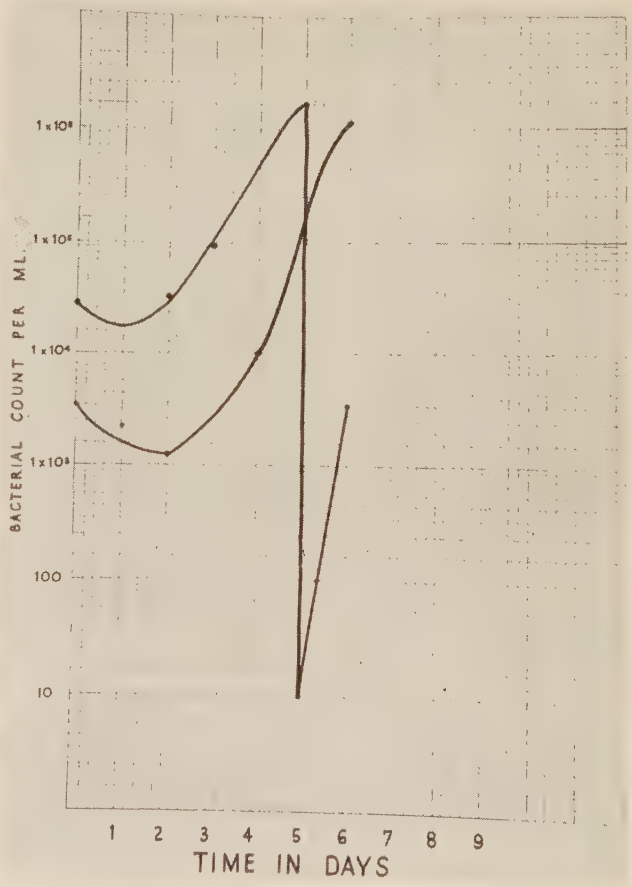

Fig. 2

The fourth factor and probably one of the more intriguing is consideration of nutrients. No nutrients are added to the pulp slurry. This quite obviously indicates that the food substances for the microorganisms are supplied by the pulp. Pulp can, at best, supply only very simple substances to the bacteria for their metabolism. Thus, the bacteria, fungi, and protozoa are metabolizing these raw materials supplied by

the pulp into all the amino acids, proteins, vitamins and growth substances necessary for not only their existence, but also their multiplication.

The growth of the bacteria has been followed daily by plate counts on serial dilutions. In some of the first studies carried out with this tank, the bacteria growth curve was established. The results of this can be seen in Fig. 2. The normal growth curve pattern is followed. Since chlorine may be used to control the microorganism content of the wet end of its paper machines, the effects of varied amounts of chlorine were studied. Figure 2 illustrates the effect of adding a theoretical 7.5 p.p.m. based on water. It is very evident that this concentration reduces the bacteria count to substantially zero within 2 hr. The count remains at or near this level for 4 to 6 hr. At the end of 24 hr. the count has climbed to 4000 colonies (bacteria) per ml. The chlorine content was followed throughout the entire experiment. Table I illustrates that there is a difference between the amount of chlorine put in and that found when immediately tested by the

Table I

Time after chlorination	$Na_2S_2O_3$ *p.p.m. of* Cl_2	*Ortho-toludine*	*Bacteria count per ml.*	*Theoretical p.p.m.* Cl_2 *put in* — *Pulp*	H_2O
				1545	7.5
10 min.	5.03	2.7	10		
2 hr.	3.91	1.8			
4.5 hr.	2.1	0.8	100		
22 hr.	2.4	0.9	4000		

standard thiosulphate test. This difference is constantly present in all experiments and has not as yet been fully explained. The thiosulphate, of course, gives the total amount of reactive chlorine present. The amount of free chlorine present is tested for by using the orthotoludine test. It is obvious that some of the chlorine is immediately tied up, presumably with organic material of the microbiological flora present and possibly with the pulp. It also becomes obvious that even though the total amount of chlorine remains at 2.5 p.p.m. and the free chlorine at 1.0 p.p.m. after 24 hr. the bacteria have managed to overcome the inhibitory effect of chlorine. Theoretically, 1 p.p.m. free chlorine is sufficient to kill any microorganism flora present. This quite obviously is not the case. The chlorine also appears inhibitory to the fungi and protozoa.

The whole answer to paper mill bacteriocides or slimicides has not yet been uncovered by this tank but the results obtained therefrom seem to have made a substantial inroad to the problem. Much more work still remains to be done.

An E. J. Albert Award paper presented at a meeting of the Delaware Valley Section of the Technical Association of the Pulp and Paper Industry, Philadelphia, Pa., May 26, 1955.

LETTERS TO THE EDITOR

Federal Specifications

To the Editor, *Tappi:*

Since it became necessary to discontinue the column on "Federal Specifications," formerly prepared by the Paper Section of the National Bureau of Standards and published at frequent intervals in *Tappi*, several requests have been received asking where information on new and revised Federal specifications is obtainable.

It may be helpful to some of your readers to know that there is an "Index of Federal Specifications and Standards," published annually, with cumulative supplements issued during each year. The "Index" is obtainable from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., at the price of $1.75 for each annual edition and supplements.

The "Index" contains lists of all Federal Specifications and Standards, Military Specifications, and General Services Administration Specifications, with directions for obtaining them.

While it lists new and revised paper specifications as they appear, it does not report the content of specifications or the nature of revisions. It would be necessary for interested persons to obtain copies of the new specifications and compare them with the superseded ones.

Robert B. Hobbs,
Chief, Paper Section
National Bureau of Standards
Washington 25, D. C.

Pulp Viscosity Test

To the Editor, *Tappi:*

In our work on complexes, we have come across a suggested TAPPI standard for the determination of pulp viscosities, and note that you are interested in receiving criticisms.

One suggestion that you may consider is that somewhere in the method you refer to the copper complex in the accepted notation, bis(ethylenediamine)copper (II) sulphate. One way to do this is to insert the scientific name parenthetically, after your first mention of the trivial name.

The only other suggestion is that you issue a word of caution concerning the evacuation of a 1-liter flat-bottomed stock bottle. Many workers have the erroneous impression that evacuation with a water aspirator does not provide enough compressive force to break glassware, and yet most of them would hesitate to use an oil pump which gives only 5% more pressure on the walls.

Raymond R. Myers
Research Assistant Professor
Lehigh University
Bethlehem, Pa.

Professional Engineers

To the Editor, *Tappi:*

At the top of page 90A of the May, 1955, issue of *Tappi* there is an item entitled "Professional Engineering Registration Laws." This news item states that a book has been issued by the Trustee Publication Fund, Jefferson City, Ohio, and can be purchased from the fund for $8.75. However, when we sent a check to the fund at Jefferson City, Ohio, our letter was returned with the notation on the envelope "No such Post Office in the State named."

Will you please investigate and advise us the correct address of the Trustee Publication Fund? Thank you for your courtesy and cooperation in this matter.

John G. Hoad, *Consulting Engineer*
Ypsilanti, Mich.

Response—The correct address is Jefferson City, Mo.

Flat Crush Test

To the Editor, *Tappi:*

As corrugated card board manufacturer, and TAPPI member, I need some information about flat crushing tests.

Morocco is a country of high humidity with the effect that, from a corrugating point of view, the rigidity of the flutes quickly decreases; I want to measure this softening. I would like to know what sort of standard tests are applied on

this point? What is the scale used? What are the average figures of machine used and where I can buy it?

P. Bayle
Cie Marocaine des Cartons et Papiers
Port Lyautey, Morocco

To the Editor, *Tappi:*

We have measured the loss or gain in flat crush value of corrugated board depending on the moisture content of the board (or on the humidity surrounding the board).

We use the Hinde and Dauch crush tester. It is manufactured by Testings Machines, Inc., 123 W. 64th St., New York 23, N. Y. This instrument is used by most companies in the courrugating field in the United States.

A good method for conditioning 10-sq. in. rings at various relative humidities to attain samples at various moisture contents for flat crush analysis of a given board is through the use of various concentrations of sulphuric acid (relative humidities vs. conc. found in International Critical Tables) in Pyrex desiccators. Another method which can be used is described in the February, 1955, issue of *Tappi* on page 120.

Milton Yezek, *Chairman*
TAPPI Container Testing Committee

Vacuum Drying Ovens

To the Editor, *Tappi:*

In the construction of our new laboratory I have thought that a small vacuum oven would be of advantage to us in high-speed drying, moisture content, and total solids content tests.

Our laboratory is constructed around a high-speed quality control chart, and a normal drying oven takes quite some time to determine even moisture content. However, in the case of moisture content I wonder whether vacuum determination would upset the real value against the normal determination in an atmospheric pressure oven. Could you advise maximum temperatures and vacuum in order that I might evaluate such a small vacuum oven to run fast check moisture when a product is out of control and very rapid determination required to control the machine.

H. L. O. Smith,
Technical Supervisor,
Paper Mill Div.
O. B. Andrews Co.
Chattanooga, Tenn.

To the Editor, *Tappi:*

To increase the rate of drying by means of a vacuum, it is important that the material be in direct contact with the heating element. Because of the decrease or absence of convection currents in a vacuum oven, a material laid on a shelf or suspended in the oven will dry at a slower rate than in a conventional oven at atmospheric pressure. Where contact with the heating element is possible, a thin material such as paper will lose moisture at a faster rate as the vacuum or the temperature increases. A thicker material, such as a disk of wood, however, will not show any faster drying in a vacuum since the drying rate is dependent upon the rate at which heat penetrates the material.

We have had no experience in determining moisture contents in a vacuum oven but believe that, under the condition mentioned above, optimum drying rates would be obtained under a vacuum and temperature as high as possible without charring or otherwise degrading the material under test.

C. E. Hrubesky, *Chemist*
Forest Products Laboratory
Madison, Wis.

To the Editor, *Tappi:*

In reply to the inquiry of H. L. O. Smith regarding rapid drying in a vacuum oven, we presume that this refers to the drying of paper or paperboard. The maximum temperature for vacuum drying should not exceed that used for drying at normal pressure, i.e., in the neighborhood of 105°C. if decomposition reactions are to be avoided although 110°C. might be tolerated for control work. Drying in a vacuum oven should give precisely the same results as drying at atmospheric pressure if in the latter instance the air in the oven is completely dry. If the specimens are air or machine dried, a good mechanical vacuum pump would be preferable to reduce the pressure in the oven to a suitably low value. A water aspirator would be satisfactory for wet specimens, but the partial pressure of water vapor in the oven would not be reduced to the suitably low value required for complete drying in reasonable times.

Drying in a vacuum oven may be faster than drying at ordinary pressure, but the drying rate depends on transfer of heat into and water vapor from the paper so that these factors are often more important than pressure in rate of water removal. Rapid drying can be achieved in commercially available instruments in which a rapid current of preheated air is passed over or through the sample, or by drying well-separated sheets of paper in an oven supplied with a stream of preheated dry air to insure rapid removal of the water vapor from the specimen.

B. L. Browning,
Research Associate
Institute of Paper Chemistry
Appleton, Wis.

Aluminum Calibrating Foil for Mullen Testers

To the Editor, *Tappi:*

We wish to obtain aluminum foil strips for calibrating our Mullen tester. Would you kindly advise us as to what concern manufactures these strips.

I. F. Jahne, *Chemist*
St. Lawrence Paper Corp.
Norfolk, N. Y.

To the Editor, *Tappi:*

Please refer us to a supplier of aluminum foil or paper test sheets which are used to test the accuracy of a Model LC Mullen Tester.

G. E. Waring
Assistant Chemist
Atlantic Sugar Refineries Ltd.
St. John, N. B., Canada

To the Editor, *Tappi:*

Standardized samples of aluminum foil in packages of ten sheets per sample are available in the following approximate ranges of burst pressure: 10, 25, 40, 55, 70, 85, 100, 115 p.s.i.

These foils are standardized on a Model "C" Mullen tester that is adjusted and operated in accordance with the method described by Faichney & Mason, *Pulp and Paper Magazine of Canada*, November, 1952, pages 123–126, using dynamically calibrated gages.

These foils may be used for checking the over-all performances of Model "C" Mullen testers; but are not intended as a substitute for calibration of either the gages or of the other components of the tester.

The charge per sample in any of the ranges listed above is as follows: to maintaining members of the Institute, $3.00; to all others, $5.00.

Because of the higher costs incurred in handling overseas

shipments, a service charge of $10 is added in the case of all orders which originate in countries outside of North America.

W. C. Truesdale, *Supervisor, Calibration Section*
Pulp & Paper Research Institute of Canada
Montreal, Que., Canada

Aluminum Dishes for T 448 m-49

To the Editor, *Tappi:*

We have received an inquiry from one of our customers who is interested in obtaining aluminum paper testing dishes for TAPPI Standard T 448 m-49. Would you be good enough to let us know of the suppliers either in Canada or the U.S.A. in order that we may obtain a quotation for our customer at the earliest opportunity.

P. Cowper
Canadian Laboratory Supplies, Ltd.
Montreal, Que., Canada

To the Editor, *Tappi:*

Aluminum paper testing dishes may be obtained from The Package Materials Laboratories, Inc., 461 Crescent Rd., Hatboro, Pa.

A. J. Winchester
TAPPI, New York, N. Y.

Floating of Pulp Sheets in Viscose Process

To the Editor, *Tappi:*

I should be grateful if you could give me some information about the problem of floating of the cellulose sheets in the pressing bath during the mercerization phase of the cellulose in its conversion into viscose.

This is, indeed, a problem which I am very interested in and I should greatly appreciate if you would notify me of some bibliographical reference or, if possible, some recent publication treating this argument.

A. Brunetti
Soc. Agricola Ind. per la Cellulosa Italiana
Torviscosa, Italy

To the Editor, *Tappi:*

West's "Bibliography of Papermaking" for 1946–50 gives these references: "Swelling and Floating Tendency of Pulp Sheets at Steeping in the Viscose Process," by E. Ringström and N. H. Apler, *Svensk Papperstidn.* 51, No. 21; 501–508 (Nov. 15, 1948); 53, No. 5; 127–132 (March 15, 1950). The *Chemical Abstracts* references for these articles are: *C.A.* 43: 2770 (1949) and *C.A.* 45: 364 (1951). In the Jan. 31, 1955, issue of this Swedish journal, there is an article on "The Floating of Cellulose Fibres During the Slurry Soaking Process," by A. Buurman and M. J. Maurice.

In the April 25, 1955 issue of the *Paper Trade Journal*, there is an outstanding paper by Forestier Walker of the American Enka Corp., Enka, N. C., entitled "How Dissolving Pulps for Viscose Are Made to Conform to Specifications." In discussing the problem of floating, Mr. Walker relates floating tendency to sheet density and describes how this property should be controlled. He also mentions there are data in the 1948 Ringström-Apler paper which enable the floating tendency of a sheet to be measured easily.

Reference

Koblitz, "Method for Determining the Floating Tendency of Pulps, *Das Papier 4:* 69–73 (1950).

Forrest A. Simmonds, *Chemist*
Forest Products Laboratory
Madison, Wis.

To the Editor, *Tappi:*

The recent article by Forestier Walker in *Paper Trade Journal* (April 25, 1955) gives an interesting discussion of the problem. I believe this paper would be of interest to Mr. Brunetti. Mr. Walker points out that floating trouble is encountered if less than 70% of the air is displaced during steeping. The difficulty may be overcome by compacting the sheet to higher density and by "ribbing."

M. Plunguian, *Director of Research*
Chemical Cotton Co.
Chattanooga, Tenn.

Corrosion of Tank Cars Carrying Spirit Liquors

To the Editor, *Tappi:*

Members of this association are actively engaged in transporting lignin liquors and sulphite spent liquor from paper and pulp mills. They are experiencing some difficulty when hauling these materials in ordinary steel tanks due to corrosion.

Has your association made any study of the corrosive properties of such liquors? If so, we would like to have your recommendations as to the proper type tanks which should be used for this purpose.

Louis Reznek, *Director Div. of Engineering and Safety*
National Tank Truck Carriers, Inc.
Washington, D. C.

To the Editor, *Tappi:*

The TAPPI Corrosion Committee, has not made any study as yet on corrosion problems encountered in the transporting of lignin liquors from the pulp and paper industry.

In checking with some of the trucking firms engaged in hauling sulphite spent liquors in this area, especially where these liquors are being used for road binders, it was found that they are using stainless steel type 304 and 304 ELC as a material for the tanks. As to service, they stated that type 304 stainless was holding up fairly well except near the top of the tank where splashing of the liquor was taking place. In these areas a pitting type of corrosion was occurring.

One of the nearby fabricators of these hauling tanks is of the opinion that type 316 stainless steel would be the best solution to the problem. He also pointed out that when returning with an empty tank it would be good practice to remove the tank cover in order for air to circulate in the tank, to help form the protective film so necessary for corrosion resistence of stainless steels. It was also stated that if the tanks were to remain empty for any length of time they should be thoroughly washed out with warm water.

S. J. Baisch, *Chairman*
TAPPI Corrosion Committee

Patterns in Machine Coated Papers

To the Editor, *Tappi:*

We have installed in our San Rafael paper mill, a Faeber print roll coating machine, to use with high solids coating color (60 to 64% solids).

The formula we are using now is approximately 78% Huber X-43 coating clay and 22% Stargum No. 10, sold by Morningstar, Nicol, Inc.; in addition to these substances, we use some sodium polyphosphate as dispersing agent and, neutral soap for gloss, both in minor quantities.

The raw stock is 42% bleached sulphite, 42% unbleached sulphite, 14% clay, and a very low sizing.

Our trouble is that some of our coated paper, principally the lightest (about 10 lb. per ream, 25 × 38—500) shows

some patterns on it, in the form of irregular almost parallel lines or marks, about $^1/_{16}$ in. wide, separated $^1/_2$ in. from each other (we include some samples) along the sheet of paper, that do not print well, either because the ink is not absorbed, or because the coating picks, precisely in the lines.

We have tried different ways to eliminate them, as for example, low or high pressures in the applicator rolls, or used soft or hard applicators; we have changed the draws between the different sections of the machine. We have also worked with various steam pressures in the driers (from 5 to 30 p.s.i.) and have changed the temperature of the hot air for drying the surface of the paper, from 200 to 400°F. The moisture content of the finished sheet (prior to calendering) has been varied from 3.5 to 6.5%. Another thing we have done, was to vary the speed of the machine from 400 to 700 f.p.m., which is our top speed now, limited by the drying capacity of the machine.

We did all this without noticing any improvement in the coated sheet. We need your valuable advice as to how to avoid the formation of said lines.

cia. de Las Fabricas de Papel
De San Rafael y anexas, S. A.
Mexico, D. F.

To the Editor, *Tappi:*

The pattern—as described—could be an accentuation of the so-called "turkey tracking" type of roll pattern or could be the ridging associated with attempting to apply a dilatant type of coating. Information would be needed on whether the parallel marks are in the machine direction or cross-machine direction in order to pin point source of pattern. Also—I am not sure whether the description of the marks is intended to mean that they are $^1/_{16}$ in. wide or $^1/_{16}$ long. If they are $^1/_{16}$ in. wide it is highly probable that the marks would then be oriented in the cross-machine direction and would be due to a dilatant type of behavior. On the other hand, if they are $^1/_{16}$ in. long, in all probability they are oriented in the machine direction and are due to film splitting type of patterning.

Whether the cause of the patterning is dilatancy or insufficient thixotropy, the correction is most apt to lie in the coating color formulation although from the description of the base stock furnish the problems could be helped considerably by the use of sizable percentages of hardwood pulps such as hardwood kraft or soda.

I am not acquainted with the behavior of Huber X-43 coating clay nor Morningstar Nicol's Stargum No. 10. If the difficulty is dilatancy, it is quite possible that a different grade of clay would permit higher solids without encountering this phenomenon. I know that Georgia Kaolin's K.C.S. Clay Southern's Lustra and Edgar's Stellar, or H. T. Clays have been used successfully in machine coating applications at the range of 60 to 64% solids.

Assuming that the trouble is due to insufficient thixotropy in the coating color, I have the following comments to make on the formula given in the attached letter.

1. The ratio of starch to clay is quite a bit higher than normally used in machine coating operation except for very light coats. Most commonly used ratio of pigment to starch is 85 to 15. The highest I have seen used was 80 to 18. You can appreciate that as the adhesive ratio goes up coating difficulties increase.

2. The letter indicates that neutral soap is used for gloss in quite minor quantities. While soap can be used for this purpose, in machine coating it performs a more important function in increasing the thixotropy of the coating color to minimize patterning of the paper. When used for this purpose you require a minimum of approximately $1^1/_2$% based on the oven-dry starch. Most machine coaters will use in excess of this and I have seen as much as $1^1/_2$% based on the pigment used in machine coating formulas. Also, the type of thixotropy producing agent used is dependent on the pigment composition among other things. Most commonly used materials are wool soap, ammonium stearate, calcium stearate, sodium stearate, sulphonated tallow and sulphonated castor oil. Only actual trials can tell which is most suited to a given operation. However, it must be kept in mind when using the sulphonated products that neoprene rubber rolls may be necessary to avoid softening of the roll coverings.

3. Sodium polyphosphate should be used in phosphate equivalent, comparable to 2 to 3% tetrasodium pyrophosphate based on the moisture-free pigment.

4. No indications are given in the latter of method of preparation of coating color. Patterning characteristics of high solids coating mixes can be very drastically affected by the type of equipment and procedure used in preparing the coating mix. It is highly desirable to blend adhesive and pigment at as high a solids level as possible (normally in the range of 70 to 75% total solids). In fact, sigma blade mixers are without question the most suitable piece of equipment to use in these systems.

Richard T. Trelfa, *Technical Director*
Watervliet Paper Co.
Watervliet, Mich.

To the Editor, *Tappi:*

For what it is worth, our experience with similar type of coating leads me to believe that the pattern referred to is caused by the coating color itself being unsuitable rheologically, or the distributing rolls becoming marked because of insufficient screening of the coating color.

I am puzzled by their attempts to correct the situation in the driers as it would indicate that they have reason to believe that the paper from the coating unit does not show the undesirable pattern.

It should be relatively easy to determine whether or not the trouble was caused entirely at the coating unit. The furnishes used and the coating formula indicated give no clue as to what might be the answer. I would suggest a close inspection of the condition of the coating and transfer rolls and further work on the rheology of the coating color.

Norman I. Bearse, *Vice-President, Production*
Champion-International Co.
Lawrence, Mass.

Sieve Analysis of Chips

To the Editor, *Tappi:*

In your method for the Sieve Analysis of Pulp Wood Chips, T 16 m-54, the size of screen openings to be used for the classification is given for chips down to $^1/_8$-in. nominal size.

Could you inquire from the Fibrous Materials Testing Committee what openings should be used in the screens to classify $^1/_2$-in. chips?

J. L. Somerville, *Chief Chemist*
Australian Newsprint Mills Ltd.
Boyer, Tasmania

To the Editor, *Tappi:*

I have had an opportunity to discuss the question raised in your letter of June 3 with Truman Pascoe and Clarence Hrubesky, both members of the Fibrous Materials Testing Committee.

A study of the series of sieves specified in T 16 for use in classifying the three nominal sizes of chips, i.e., $^7/_8$, $^3/_4$, and $^5/_8$ in. showed:

1. As the nominal size decreases in $^1/_8$-in. intervals, the openings in the sieves in a given position (column) decrease $^1/_8$ in. in diameter in all positions except the fifth (the sieve with the smallest openings in the series).

2. In each series (line) the openings in successive sieves decrease 1/4 in. in diameter except between the fourth and fifth positions.

3. In each series it would be expected that most of the chips having the nominal size would pass the second and be retained on the third sieve.

We also agreed that it did not seem to be practicable to have a screen in the fifth position with openings less than 1/8 in. in diameter.

On the basis of the above, then, we would suggest to Mr. Somerville the following series for 1/2-in. nominal size chips:

Diameter of openings, in.	*Position of sieve*
	7/8, 5/8, 3/8, 3/16, 1/8

I understand that the use of 1/2-in. chips has been advocated lately, especially in the pulping of hardwoods by semichemical processes and that it is being done in one or two places. I think your suggestion that T 16 be revised to include 1/2-in. chips is good. I will write to the members of the committee for their ideas.

E. R. Schafer, *Chairman*
TAPPI Fibrous Materials Testing Committee

To the Editor, *Tappi:*

I don't know whether 1/2-in. chips are used in the U.S.A., and if not it is questionable whether they should be included in T 16 m. However, for a nominal chip size of 1/2 in. the screen openings, from a practical as well as mathematical point of view, would seem to be limited to 7/8, 5/8, 3/8, 1/8, and 1/16 in., if 5 screens were used. My mathematics on this (subject to correction) is as follows:

Let A = average of the screen openings specified for the 5 screens, and R = ratio of A divided by nominal chip size; then, for the four different nominal chip sizes we would have:

Chip size, in.	A	R
7/8	0.75	0.86
3/4	0.6375	0.85
5/8	0.525	0.84
1/2	0.4135	0.83

The ratios (R) are essentially the same.

Roger C. Griffin, *Chairman*
TAPPI Standards Committee

Corrosion in Chlorine Dioxide Plants

To the Editor, *Tappi:*

In the January, 1955 issue of *Tappi* there is an article on page 44 about a corrosion study in a chlorine dioxide pulp bleaching plant. In the list of materials of construction under item 9 Vitroplast is mentioned as excellent even in a mixer, and in item 19 Atlastavon 30 is also mentioned as excellent.

We have not been able to find the companies which manufacture these materials. Also regarding LaBour R-55 and Chlorimet 3 we are not fully oriented. We would much appreciate information regarding these materials and the source of supply.

Ragnar Mounberg
Rauma-Repola Oy
Rauma, Finland

To the Editor, *Tappi:*

This is in response to your request for information about materials of construction listed in the paper: "A Corrosion Study in a Chlorine Dioxide Pulp Bleaching Plant."

Vitroplast is an acidproof cement made by Atlas Mineral Products, Mertztown, Pa., and is used as a jointing compound for ceramic tile.

Alastavon is a plasticized polyvinyl chloride made by Atlas Mineral Products. It is bonded to steel by an adhesive.

LaBour R-55 is a nickel base alloy produced by LaBour Pump Co., 1561 Sterling Ave., Elkhart, Ind., and the nominal composition is: 23% Cr, 53% Ni, 4% Cu, 4% Mo, 4% Si, 2% W, 0.20% max. C, and balance Fe.

Chlorimet 3 is a nickel base alloy produced by the Duriron Co., Dayton, Ohio, and its nominal composition is: 60% Ni, 18% Cr, 18% Mo, 3% Fe, and 0.07% C.

H. O. Teeple
International Nickel Co.
New York, N. Y.

Semichemical Pulping Systems

To the Editor, *Tappi:*

We have read with interest the article by Roderick O'Donoghue entitled "Neutral Sulphite Semichemical Recovery Systems" which appeared in *Tappi* 38, No. 6: pages 162A–167A, June, 1955. In a portion of this article, Mr. O'Donoghue has presented a description and a flowsheet of a recovery process which he has called "The Institute of Paper Chemistry Process."

We have been working for several years on various aspects of the neutral sulphite recovery problem, under the sponsorship of a sizable number of pulp and paper companies in the United States. So far, this group of companies has not approved the release of the results of our work for publication, and therefore we have no authority to discuss them here or elsewhere.

We are not in the habit of writing critical letters to the editor of this or any other journal. Nevertheless, in order to keep faith with our sponsors, it seems necessary to state publicly that we are totally unaware of Mr. O'Donoghue's intent to publish a description of a process attributed to us, and that he had no authority from us to do so.

Mr. O'Donoghue has correctly described, in general terms, *one* of several approaches to the recovery problem which we have studied. However, many of the details of his process description, flowsheet, and chemical reactions are incorrect.

Roy P. Whitney, *Research Associate*
The Institute of Paper Chemistry
Appleton, Wis.

To the Editor, *Tappi:*

You called me, saying that you are going to publish Roy P. Whitney's protest against what I said about "The Institute of Paper Chemistry Process," in my article titled "Neutral Sulphite Semichemical Systems."

I am very sorry if I published information which was embarrassing to him and his organization.

The information I published in the article was considered general knowledge and did not come from him.

If there are any errors in what we have described, we would like to be so advised, but feel they are substantially correct.

Our main object in writing the article was to be of service to the general public, giving them information on various recovery systems that are being considered, and this I thought would be a service to the industry.

Roderick O'Donoghue
Roderick O'Donoghue and Co.
New York, N. Y.

Twelfth Agricultural Fibers Conference

Alton, Ill., Oct. 13–14, 1955

EMPIRE STATE JUNIOR AWARD PAPERS

Empire States Section, Lake Placid, N. Y., June 9–11, 1955

Centri-Cleaning of Sulphite Pulp

DONALD D. ANDERSON

In recent years, as market conditions have become more competitive, the desirability of higher quality has become increasingly evident. The cleanliness of pulp is very important in maintaining high quality for the pulp must of necessity be relatively free from dirt specks and other foreign particles. In years gone by, cleaning of the wood was considered sufficient for most pulp-making processes but the higher standards of today can no longer be met by the old methods. Scrupulous cleaning of wood to achieve the standards of today would cost prohibitively so other means have been devised to improve the cleanliness. One of the more recent of these developments makes use of the forces generated in centrifugal motion.

PRINCIPLES OF OPERATION

The principal behind centrifugal cleaning is not new. Rifflers have been used for many years in removing objectionable dirt and foreign material from a pulp suspension the operation of which depended mainly on the particles having a higher specific gravity than the pulp fibers. The same principle is utilized in centrifugal cleaners but better separation is effected by increasing the gravitational effect on the foreign particles. This higher gravitational effect is produced by subjecting the pulp suspension to intense centrifugal action.

The Centri-Cleaners at International are classified as the no. 600 series and consist essentially of a hollow truncated cone 3 in. in diam. at the top and $^1/_4$ in. diam. at the bottom with an overall length of 32 in. The cone is provided with a tangentially situated stock inlet and a cleaned stock outlet located centrally at the top while rejects are discharged at the truncated apex of the cone.

When the pulp suspension is introduced tangentially at the top, the liquid commences to spin rapidly and, while spinning, moves down the cone forming what is known as a free-vortex, commonly seen when water drains from a bath tub. The particles of heavier specific gravity migrate to the outer periphery of the vortex as a result of the centrifugal force generated, where they tend to form a heavier outer layer. As the liquid moves down the cone this heavier layer becomes smaller and smaller in cross-sectional area until it becomes small enough to be discharged through the orifice at the bottom. It is apparent that efficient operation dictates that the fraction removed at the bottom must be a reasonable percentage of the input volume and therefore contains usable fiber which can be reclaimed by secondary, tertiary, and, in some instances, quaternary stages. The cleaned stock in the suspension, unable to escape at the bottom, forms a centrally ascending column which is removed through the central opening at the top.

An idea of the forces involved in the Centri-Cleaner can perhaps be better grasped by a few mathematical computations.

Donald D. Anderson, Assistant Sulphite Superintendent, International Paper Co., Palmer, N. Y.

A theoretical relationship has been established for a free-vortex which states that the tangential velocity is inversely proportional to the radius. As the rated capacity of the unit is 20 g.p.m. the tangential velocity at 3 in. diam. can be assumed to be close to 33 f.p.s. and the tangential velocity at $^1/_2$ in. diam. will then be 198 f.p.s. These values can then be converted to revolutions per minute and the centrifugal force calculated on the basis of the formula.

$$F = 3.0 \times \text{radius} \times (\text{r.p.m.})^2 \times 10^{-5}$$

where F is the centrifugal force in terms of number of times gravity and the radius is measured in inches. On this basis the r.p.m. at 3 in. diam. is 2520 and at $^1/_2$ in. diam. the r.p.m. is 90,900. Likewise, the centrifugal force at 3 in. diam. is 286 times the force of gravity and at $^1/_2$ in. diam. is 61,900 times the force of gravity. This relationship for a free vortex has been proved to be mathematically sound at the Howard Smith Paper Mills by measuring the revolutions per minute in a transparent Centri-Cleaner stroboscopically. Thus, the tremendous increase in gravitational effect that can be produced in a small cone is readily evident. This increased gravitational effect is responsible for the efficient separation of dirt and foreign material from the pulp suspension.

PLANT INSTALLATION

The cleaners at International are located in the sulphite screen room. Stock from the blow pits is passed through two Allis-Chalmers vibratory knotters with $^3/_{16}$-in. openings operating in parallel. Accepted stock from the knotters is regulated at 0.7% consistency to two primary Cowan screens equipped with 0.050-in. screen plates. It is planned, at present, to replace these screen plates with plates that are 0.060 in. on the inlet side and 0.050 in. on the reject discharge side. It is expected that this change will increase the load on the cleaners and operating conditions may be somewhat changed. The rejected stock from the primary screens is rescreened on a secondary Cowan equipped with 0.060-in. plates. Accepted stock from all three screens is collected in a tile tank which supplies the pump for the primary Centri-Cleaners. Accepted stock from the cleaners is thickened on deckers and sent either to the bleach plant or the beater room as required.

The cleaners themselves are situated in three stages: a primary stage containing 256 units, a secondary stage of 40 units, and a tertiary stage of 12 units. Each unit consists of a cone with a 3-in. diam. head, a $^1/_2$-in. feed, a $^5/_8$-in. accepted outlet, and a $^1/_4$-in. reject orifice. The entire unit is constructed of hard rubber, weighs about 3 lb., and has a nominal capacity of 20 g.p.m. when operated at 50 p.s.i.

Stock is pumped to the primary stage through a 12-in. header. The accepted stock from the primary cleaners goes directly to the deckers while the rejects are collected in a tile collection box and pumped to the secondary stage. Accepted stock from the secondary stage joins the accepted stock from the primaries in going to the deckers while the rejects are collected as before and pumped to the tertiary stage. The accepted stock from the tertiary stage is recycled through the secondaries by adding it to the primary rejects while the tertiary rejects are sewered as having no further value. A by-

pass line from the primary and secondary accepted line is fitted with an air-operated valve connected with a float in the tile tank feeding the primary pump. This by-pass allows some of the stock to be recycled if necessary to keep a constant head on the pump and keep the cleaners operating at full capacity.

The entire Centri·Cleaner installation is very compact and occupies a floor space of less than 400 sq. ft.

TESTING PROCEDURE

Tests performed on the Centri·Cleaner system were made as follows:

1. The pressure of the incoming stock was held at 50 p.s.i. for the primary and secondary stages and 40 p.s.i. for the tertiary stage.
2. The reject flow of the three stages was determined by measuring the time required to fill a 2-qt. calibrated can. Twenty units in the primary stage, 10 units in the secondary stage, and 5 units in the tertiary stage were sampled as being representative of the whole. The primary accepted flow was also determined by measuring the time required to fill a 55-gal. drum to a predetermined level.
3. Consistency samples were collected from the Cowan accepts, primary accepts, primary rejects, secondary feed, secondary rejects, tertiary feed, tertiary rejects, and the accepted stock to the deckers. A sufficient number of tests were made to determine a reliable average.
4. Samples were also taken at various points for use in a Clark fractionater to determine the effect of the cleaners on fiber size.
5. Measurement of the amperage consumed by the various motors in the cleaner system were made by the electrical department in determining the horsepower consumed per ton of pulp.

Method of Calculating

Since the rejects have open discharges, the accurate measurement of the flow and the consistency is a simple task. Measuring the flow of the feed or accepts is difficult, however, because the feed enters under pressure while the accepts discharge in a closed header against a slight back-pressure. This problem can be solved by measuring the consistency of the feed or accepts, and determining the flow becomes a matter of selecting the proper material balance or combination of balances.

The three main factors used in calculating the various material balances were the consistency, the liquid flow in gallons per minute and the stock flows in moisture-free pounds per hour at each point in the system. It is obvious that if any two of these three factors are known, the third can be calculated. In each stage, the feed is necessarily equal to the sum of the rejects and accepts both in respect to gallons per minute and moisture-free pounds per hour. In considering balances between stages only moisture-free pounds per hour are used because the rejects are diluted for passage through the succeeding stage. For instance, the secondary rejects are equal in moisture-free pounds per hour to the tertiary feed. Likewise, the secondary feed in moisture-free pounds per hour is equal to the sum of the primary rejects and the tertiary accepts.

In similar fashion, the desired values at the various points in the system can be computed. A complete tabulation of the results of the balance appears in Table I.

EXPERIMENTAL RESULTS

Fiber rejection amounts to 5.4% of the fiber input in the primary stage, 27.7% in the secondary stage, and 39.1% in the tertiary stage. The liquid rejection remains fairly constant in the three stages amounting to 4.1% in the primary stage, 4.8% in the secondary stage, and 4.6% in the tertiary stage. These figures indicate that there is a definite thickening of the rejects occurring in the cleaners and this effect becomes more noticeable in each succeeding stage. The consistency samples of the rejects also substantiate this effect. This thickening becomes a serious disadvantage in considering a quaternary stage as the rejects in the tertiary stage are thickened to a consistency of 1.39% from an input consistency of 0.16%.

The cleaners, operating with an input from the Cowan screens of 121 air-dry tons per day at a consistency of 0.42%, accept 120 tons of stock for the deckers, reject about 1 ton or 0.8% of the input, and recycle about 17 tons or 8% of the primary feed. Theoretically, with no recycling, the cleaners will accommodate 138 tons per day at an input consistency of 0.42%. If the consistency is raised to 0.50%, as recommended as optimum by the manufacturers, it is estimated that the cleaners could accommodate 150 tons per day with little or no recycling.

Table I

	Consistency, g./l.	*Moisture-free lb./hr.*	*G.p.m.*	*Air-dry, tons*
Feed from screens	4.17	9,044	4,338	120.6
Primary feed	4.09	10,363	5,073	138.1
Primary accepts	4.03	9,801	4,864	130.6
Primary rejects	5.39	562	209	7.5
Secondary feed	1.48	674	911	9.0
Secondary accepts	1.12	486	866	6.5
Secondary rejects	8.45	188	44	2.5
Tertiary feed	1.56	188	241	2.5
Tertiary accepts	0.97	112	230	1.5
Tertiary rejects	13.90	76	11	1.0
Recycled	3.59	1,319	735	17.6
Accepts to deckers	3.59	8,968	4,995	119.8

There were indications from visual inspection of the tertiary rejects that long shives were not readily removable by the cleaners but the efficiency was good on short chunky shives. Since shives act the same as colored fibers, it is logical to assume that the short chunky shives have a higher specific gravity than the long shives. Following this reasoning indicates that short fibers of high specific gravity would also be rejected by the cleaners. To ascertain the correctness of this assumption, fiber classifications of the feed, accepts and rejects of all three stages were made using a Clark fractionater. The fractionater is used to measure the percentage by weight of the solid material retained on successively finer screens, in this case 20, 35, 65, and 150-mesh screens.

Of the primary feed, 61% of the fiber was retained on a 20-mesh screen while only 32% of the primary reject fiber was large enough to be retained on the 20-mesh screen. This rejection of the shorter fiber becomes increasingly evident in each succeeding stage until, in the tertiary rejects, the amount retained by a 20-mesh screen has been reduced to 8%, the major proportion of which is in the form of large dirt specks, etc. Another means of evaluating the rejection of shorter fibers is indicated by the total percentage retained on the 20 and 35-mesh screens. Of the primary feed, 73% was larger than 35 mesh while the tertiary rejects contained 40% larger than 35 mesh (see Table II).

Table II

	Per cent retention, screen mesh				
	20	*35*	*65*	*150*	*Pass 150*
Primary feed	60.6	12.4	12.8	4.8	9.4
Primary accepts	62.6	12.0	11.4	3.8	10.2
Primary rejects	32.4	24.0	23.0	10.0	10.6
Secondary feed	25.6	23.6	29.0	9.2	12.6
Secondary accepts	37.2	18.8	19.6	9.2	15.2
Secondary rejects	13.8	31.6	31.0	11.8	11.8
Tertiary feed	11.2	32.2	34.2	13.4	9.0
Tertiary accepts	5.4	28.0	32.4	13.6	20.6
Tertiary rejects	8.2	31.4	34.0	11.8	14.6

The power consumption for pumping purposes for the entire installation amounted to 1.5 hp.-day per ton about 80% of which was consumed in the primary stage.

The final criteria in evaluating the performance of the cleaners is, of course, the over-all efficiency of dirt removal.

This evaluation was based on the dirt counts performed by the research division and compares the 3-month period following installation against the 3-month period immediately preceding the installation of the cleaners. Dirt counts previous to installation averaged 44 p.p.m. of shives and 21 p.p.m. of other dirt compared to an average count after installation of 21 p.p.m. of shives and 1 p.p.m. of other dirt. Therefore, the cleaners remove about 50% of the shives and 95% of the other dirt.

CONCLUSIONS

In a Centri•Cleaner installation of the no. 600 series containing 256 primary cleaners, 40 secondary cleaners, and 12 tertiary cleaners, and occupying a total floor space of less than 400 sq. ft. 138 tons of sulphite at 0.42% consistency can be cleaned of 50% of the shives and 95% of the other dirt with an overall rejection of less than 1% and a power consumption of 1.5 hp.-days per ton.

An Empire State Junior Award paper presented at a meeting of the Empire State Section of the Technical Association of the Pulp and Paper Industry, Lake Placid, N. Y., June 9–11, 1955.

Kraft Pulping of Various Species of Hardwoods from Northern and Southern United States

MAUNG MAI AUNG

This project was started on July 13, 1954, and because of previous commitments, experimental work had to be terminated on Sept. 10, 1954. The time was insufficient for a complete study of all the pulping and bleaching variables for eight wood species. Three important variables were studied for each species: (1) effect of per cent active alkali on yield, (2) effect of sulphidity on yield, and (3) bleach requirements at maximum screened yield. A complete study should consider the effects of time and temperature.

Chemical composition of the woods was studied by the staff of Central Technical Department, St. Regis Paper Co.

The following wood species were studied:

Botanical name	*Common names*	*Source*
Populus tremuloides	Poplar, aspen	Northern New York
Fagus grandifolia	Beech	Eastern New York
Betula lutea	Yellow birch	Eastern New York
Betula papyrifera	White birch	Eastern New York
Acer saccharum	Hard maple, sugar maple	Eastern New York
Acer rubrum	Soft maple, red maple	Eastern New York
Liquidambar styraciflua	Red gum	Southern Alabama
Querous sp.	Red oak	Southern Alabama

LITERATURE SURVEY AND CHOICE OF CONDITIONS

Concentration and Liquor Ratio

Concentration and liquor ratio depend upon each other. If one varies, the other is automatically varied. Therefore, it is impossible to keep both constant when the effects of more important variables—such as chemical consumption, sulphidity, etc.—are being studied. In this investigation, it was decided to keep the concentration constant as it has more effect on the rate of delignification, bleachability, and yield. So far as the liquor is sufficient to penetrate all the chips homogeneously, the variation of the volume of liquor should not have much effect on yield and bleachability. According to Bray and Martin, the liquor ratio of 3:1 seems to be quite good as they used it as minimum ratio in the sulphate pulping of sweetgum. Therefore, at least the ratio of 3:1 was used throughout the experiment.

As the digester used was very small, there were two problems to be solved if the concentration was to be fixed. If the concentration is lowered to 30 grams per liter, even with the maximum volume of liquor which the digester can take, the weight of the wood has to be so lowered for a required chemical percentage that the pulp produced is not sufficient for bleaching. On the other hand, if a concentration of 50 grams per liter is used, it is found that when chemical percentage is reduced to about 14%, the liquor to wood ratio falls below 3:1.

As the hardwoods consume less chemical than the softwood, it was first assumed that the chemical requirement would vary from about 15% (expressed as Na_2O) to about 17%. Fifty grams per liter was chosen initially. However, poplar gave 50% accepted yield with 14% chemical. There was a possibility that some of the remaining hardwoods, which might have less lignin than poplar, might have to be pulped with less chemical than 14%, which meant the liquor to wood ratio would fall below 3:1. Thus, with the exception of poplar, all the hardwoods were pulped with the concentration of 40 grams (expressed as Na_2O) per liter.

Chemical Percentage on Moisture-Free Wood

It is well known that hardwoods contain more pentosans and less lignin than softwoods. Normally, for softwoods, the percentage of chemical, expressed as Na_2O, on oven-dried wood varies from 18 to 20%. Evidently, hardwoods will need less chemical than softwoods because of the lower lignin content. It was, therefore, decided to start with a lower amount of chemical than for softwoods.

Based on the lignin content of the wood, three percentages of chemical were chosen. The first cook was always made with the intermediate chemical percentage. If very soft pulp and low screenings were obtained, the higher chemical percentage was discarded and a series of cooks was made with lower chemical percentages; if very coarse pulp and high screenings were obtained, the lower chemical percentage was discarded.

From the curves of yield versus per cent chemical, the maximum yield of screened pulp was estimated.

Sulphidity

According to Casey, sulphidity varies in commercial kraft cooking from 20 to 30%, 25% being a good average. Therefore, in studying the effect of per cent chemical, sulphidity was held constant at 25%.

Using the per cent chemical which appeared to give maximum screened yield, the effect of sulphidity was studied in the range from 15 to 25%. There was insufficient time to study a wider range and the 15 to 25% range was chosen at the request of the company. Modern kraft recovery-units seldom maintain sulphidity above 20%, and the possible benefits of raising the sulphidity above 20% are of considerable interest.

Time, Temperature, and Pressure

Time and temperature are very important variables in kraft pulping. A complete study should include these effects, but the investigator had a very limited time and these variables could not be studied.

A logical time and temperature had to be chosen based on a survey of the literature. According to Casey, 4 to 6 hr. cooking time is generally used for bleachable grades of kraft pulp, and the temperature is brought up slowly. Since bleaching is a part of this investigation, it was decided to use a total of 4 hr., with 2 hr. for bring-up.

Since the time chosen was rather long, a maximum temperature of 160°C. was used for all woods, which is the lowest temperature commonly used in kraft pulping. At this temperature, pressure varied from 90 to 100 p.s.i.g.

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To reduce the false pressure caused by volatile gases given off in the initial stages of cooking, pressure was relieved every half hour during the first 2 hr.

PROCEDURE

Wood Preparation

All wood samples were received rough and were peeled by hand with a draw shave. The peeled logs were chipped in a commercial Carthage chipper and screened through a Williams chip classifier. The chips which passed a 1-in. mesh screen and were retained by a $^1/_4$-in. mesh screen were used for pulping, discarding oversize and fines.

Moisture content was determined by oven drying a sample, and digester charges of known weight were stored in moisture-proof bags.

Preparation of Cooking Liquor

The required weights of caustic soda and sodium sulphide were dissolved in hot water (approximately 180°F.) and the solution was diluted with hot water to give the required volume. Usually, the chemicals and volume were twice the amount required for the cook, one half being charged to the digester and one half being used for verification of the chemical composition by volumetric analysis. Errors were minimized by preparing a double batch. The liquor was made just before charging and the analysis was performed as soon as possible. No carbonate was added, and no black liquor was used for dilution.

Cooking Conditions

All digestions were made in a 1 lb. (2500 cc.) horizontal rol tating stainless steel digester, externally heated with electrica-

Table I

Cook no.	Cooking chemicals: Sulphidity, %	Calculated chemical, %	Chemical from analysis, %	Liquor to wood ratio	Liquor volume, ml.	Yield percentage on oven-dry pulp: Accepted, %	Rejects, %	Total, %	K no.	Pulp for bleaching	Bleach no.	Bleaching chemicals: Chlorine in 1st stage, %	Chlorine in 3rd stage, %	Total chlorine, %	G.E. brightness
Poplar															
M-103	25	14	13.2	2.8:1	434	51.0	12.0	63.0	16.0	M-104	I	4.29	1.06	5.35	71.5
M-102	25	15	14.8	3:1	488	55.0	7.5	62.5	15.7		II	4.29	1.36	5.65	80.0
M-100	25	16	16.2	3.2:1	554	57.5	1.75	59.25	14.8		III	4.29	1.88	6.17	85.1
M-104	25	17	17.4	3.4:1	600	60.0	2.01	62.01	14.0						
M-106	20	17	16.5	3.4:1	600	56.8	1.27	58.07	14.6						
M-107	15	17	16.8	3.4:1	600	57.0	2.31	59.31	16.0						
Beech															
M-115	25	14	13.8	3.5:1	1172	42.0	5.0	47.0	13.8	M-114	I	3.82	0.67	4.50	79.0
M-113	25	15	14.9	3.75:1	1306	43.5	3.5	47.0	12.8		II	3.82	1.18	5.01	81.5
M-114	25	16	16.5	4:1	1400	46.0	0.9	46.9	13.0		III	3.82	2.28	6.11	86.35
M-116	20	16	15.8	4:1	1412	45.0	1.9	46.9	13.6						
M-117	15	16	15.5	4:1	1420	44.0	2.5	46.5	13.9						
White Birch															
M-123	25	13	13	3.25:1	917	42	11.7	53.7	13.3	M-118	I	3.16	0.49	3.66	62.0
M-120	25	14	13.9	3.5:1	1000	47.3	4.65	51.95	13.3		II	3.16	0.99	4.15	70.95
M-118	25	15	15.7	3.76:1	1088	49	1.5	50.5	13.1		III	3.16	1.84	5.01	81.9
M-125	20	15	14.9	3.76:1	1096	49	1.1	50.1	14.2						
M-126	15	15	15.4	3.76:1	1102	47	4.4	51.4	15.6						
Yellow Birch															
M-110	25	13	13.4	3.3:1	1000	44.8	13.5	58.3	14.9	M-108	I	4.36	1.24	5.6	74.0
M-109	25	15	14.8	3.7:1	1172	54.5	0.26	54.76	13.9		II	4.36	1.67	6.03	79.0
M-108	25	14	13.6	3.5:1	1086	56.9	0.63	57.53	14.0		III	4.36	2.26	6.62	82.5
M-112	20	14	14.5	3.5:1	1102	52.3	2.22	54.52	14.3						
M-111	15	14	14.2	3.5:1	1118	52.0	2.25	54.25	14.5						
Soft Maple															
M-133	25	13	13.5	3.2:1	1000	42.6	9.6	52.2	14.0	M-129	I	3.85	0.50	4.35	68.15
M-131	25	14	14.5	3.5:1	1086	45.4	2.7	48.1	13.9		II	3.85	0.92	4.78	79.9
M-129	25	15	15.5	3.76:1	1172	46.2	1.6	47.8	12.9		III	3.85	1.72	5.58	85.2
M-139	20	15	15.0	3.76:1	1179	46.0	2.0	48.0	13.4						
M-140	15	15	15.2	3.76:1	1186	44.9	4.3	49.2	13.7						
Hard Maple															
M-124	25	14	13.6	3.5:1	1038	39	10	49	15.1	M-122	I	3.89	0.5	4.39	69.4
M-119	25	15	15.2	3.75:1	1158	45.2	2.46	47.66	14.4		II	3.89	0.92	4.82	81.7
M-122	25	16	15.8	4:1	1208	46.4	1.17	47.57	13.0		III	3.89	1.75	5.65	84.65
M-127	20	16	16.4	4:1	1216	43	0.71	43.71	13.8						
M-141	15	16	16.3	4:1	1223	43	3.84	46.84	13.9						
Red Gum															
M-136	25	13	13.3	3.2:1	838	36.8	11.5	48.3	18.4	M-138	I	4.64	0.50	5.14	68.4
M-134	25	14	13.8	3.5:1	938	42.2	4.0	46.2	16.8		II	4.64	0.79	5.43	76.2
M-138	25	15	15.1	3.76:1	1024	42.0	2.43	44.43	14.9		III	4.64	1.60	6.24	83.9
M-142	20	14.5	14.4	3.58:1	970	40.0	2.70	42.7	15.9						
M-143	15	14.5	14.9	3.58:1	977	41.0	1.20	42.2	16.7						
Red Oak															
M-132	25	14	13.8	3.5:1	973	44	5.85	49.85	13.7	M-130	I	2.83	0.94	3.78	79.5
M-128	25	15	15.5	3.76:1	1059	45	3.5	48.5	13.0		II	2.83	1.74	4.58	84.0
M-130	25	16	15.9	4:1	1208	46	1.57	47.57	12.4		III	2.83	2.67	5.51	85.6
M-135	20	16	16.5	4:1	1151	44.6	2.7	47.3	12.6						
M-137	15	16	16.4	4:1	1158	43.9	4.85	48.75	12.5						

strip heaters. Speed of rotation was 2 r.p.m. The digester was equipped with temperature and pressure indicators and a valve relieving to the atmosphere. Maximum pressure was 100 p.s.i.g. and maximum temperature averaged 320°F. (160°C.) for all cooks.

Breaking, Washing, and Screening

As the digester had to be relieved to atmospheric pressure and dumped, it was necessary to break up the cooked chips by mechanical means. This was done by stirring the chips in hot diluted black liquor for 15 min. with a Lightning mixer. The pulp was washed in a 14 by 20-in. wooden box with 40-mesh stainless steel screen bottom. After washing with hot water and then with cold water, the pulp was screened through 0.008-in. cut Valley flat screen.

The screened pulp was diluted to a known volume in a large can and the consistency found by the usual method. The screened or accepted yield was calculated from the consistency. Screenings were dried overnight in an oven and weighed.

The pulp was then thickened in the screen bottom box, squeezed, and stored in moistureproof bags for bleaching.

Bleaching

Three-stage bleaches, consisting of: (a) chlorination, (b) caustic extraction, and (c) hypochlorite, were made on all the pulps at maximum yields as follows: (1) chlorination of 150 grams of pulp wash; (2) caustic extraction wash; (3) divide into three equal parts; (4) bleach the 50-gram pulp batches with calcium hypochlorite wash; (5) make brightness pad 24 hr. in conditioned room and determine G.E. brightness.

Bleaching conditions

	Chlorination	*Caustic extraction*	*Hypochlorite*
Available chlorine, %	65% of chlorine as demanded by permanganate number	...	Three levels—one batch equal to, one batch less than, one batch more than, the available chlorine as demanded by the permanganate number of extracted pulp
Caustic, %	...	1–2	....
Temperature, °C.	25	65	35
Time, hr.	1	1	2–3
pH	...	Above 10[a]	Above 8[a]
Consistency, %	3	10	10

[a] Maintained above 10 and 8 respectively by adding caustic.

Curves showing the relation between the total chlorine consumption and the G.E. brightness were drawn, and the required chlorine consumption for 80 G.E. brightness was determined from the curves.

RESULTS

Chemical Consumption and Yield

All the eight species of hardwoods can be pulped easily by the kraft process. The chemical consumption and the yield vary from species to species as follows:

Species of wood	*Maximum accepted yield, %*	*Chemical consumption, %*
Poplar	60.0	17.0
Yellow birch	56.9	14.0
White birch	49.0	15.0
Hard maple	46.4	16.0
Soft maple	46.2	15.0
Red oak	46.0	16.0
Beech	46.0	16.0
Red gum	43.5	14.5

Note: The yield is expressed as percentage of oven-dry pulp on oven-dry wood and the chemical expressed as Na_2O percentage on oven-dry wood.

Sulphidity and Yield

All the eight species of wood tend to give higher yield with higher sulphidity. Beech and red oak show increasing yield over the entire range from 15 to 25% sulphidity. White birch and soft maple show increasing yield between 15 and 20% sulphidity, but no increase above 20%. The remaining species—poplar, yellow birch, hard maple, red gum—show increasing yield between 20 and 25% sulphidity, but no increase below 20%.

Bleaching Properties

All the eight kinds of hardwood pulps are easily bleached, but the chlorine consumption for 80 G.E. brightness varies from species to species, as shown below.

Species	*Total chlorine, %*	*Permanganate number*
Yellow birch	6.2	14.0
Red gum	5.7	14.9
Poplar	5.65	14.0
Beech	4.85	13.0
Soft maple	4.80	12.9
Hard maple	4.72	13.0
White birch	4.70	13.1
Red oak	3.86	12.4

Chemical Components of Wood

Each of the chemical components of the woods has been examined to determine its influence on the sulphate pulping properties of the woods. The only clear correlation is between lignin content and yield. As would be expected, yield decreases as lignin content increases. This is true of both total yield and screened yield; it is true of both maximum screened yield and screened yield obtained with constant chemical usage.

Table II. Wood Analysis

	Species							
	Poplar	*Yellow birch*	*White birch*	*Beech*	*Hard maple*	*Soft maple*	*Red oak*	*Red gum*
Ash, %	2.10	0.47	0.35	0.39	0.38	0.38	0.44	0.44
Extractives								
Ether, %	0.59	0.55	0.16	0.22	0.24	0.22	0.33	0.13
Alcohol, %	1.49	3.39	1.35	0.91	2.31	1.13	3.31	1.88
Alcohol-benzene, %	0.16	0.10	0.09	0.14	0.09	0.08	0.11	0.08
Water, %	1.72	1.30	0.96	1.63	1.78	1.70	1.73	2.18
Soluble in 1% caustic, %	12.7	16.5	17.1	13.2	17.7	15.4	18.7	15.2
Lignin, %	16.9	19.6	19.4	21.1	20.8	22.4	20.6	22.3
Pentosan, %	10.5	33.0	22.6	19.1	17.6	23.8	17.1	16.9
Holocellulose, %	77.7	78.6	80.6	72.7	76.3	75.0	71.3	75.4
Alpha-cellulose, %	50.8	47.8	41.2	43.4	45.3	49.8	44.2	46.5

When yield is charted against lignin, certain secondary relations appear. Maximum screened yield tends to increase with increasing alpha-cellulose content. Rejects obtained, using constant chemicals, tend to be low when pentosan content is high. The amount of chemical required for maximum screened yield bears the same apparent relation, logically, since maximum screened yield is usually obtained when rejects are reduced to a low value.

CONCLUSIONS

1. This work demonstrates conclusively that the major variable in kraft pulping of hardwoods is wood species. Hardwoods seldom occur in large stands of a single species, mixed stands of four or more species being the rule. In tropical and subtropical areas, it is normal to find 30 or more species in mixture. Data on the comparative pulping properties of hardwoods are essential in order to determine which species can be harvested and pulped as a group.

2. The yield of hardwood kraft pulp is generally improved by maintaining high sulphidity in the cooking liquor. Since special methods, such as black liquor oxidation or addition of elemental sulphur, are required to obtain sulphidities above 20% with the latest recovery systems, manufacturers should balance the cost of such methods against the value of the additional pulp. It also appears that the possible value of increasing sulphidity depends on the species being pulped.

3. Hardwood kraft pulps are obtained in a narrow range of permanganate numbers, with a relatively wide range of cooking conditions, and there is little difference in permanganate numbers among various species. The choice of species mixtures should present fewer problems in bleaching than in cooking. Permanganate number appears to be a reasonably accurate estimate of bleach requirements of hardwood kraft pulps, regardless of species.

4. Analysis of the chemical components of hardwood species shows promise as a means for estimating the results of kraft pulping. The yield of accepted pulp appears to decrease with increasing lignin content, this relationship being modified by a secondary effect in which the yield increases with increasing alpha-cellulose content. There is an apparent, but unexplained, relation between rejects and pentosans.

An Empire State Junior Award paper presented at a meeting of the Empire State Section of the Technical Association of the Pulp and Paper Industry, Lake Placid, N. Y., June 9–11, 1955.

The investigator wishes to express his appreciation to the Central Technical Department of St. Regis Paper Co. for assigning this project, which served as useful preliminary work for the investigator's proposed graduate thesis, called "Suitability of *Bombax Malabarium* for Kraft and NSSC Pulping."

The investigator owes gratitude to R. L. Miller and R. P. Hamilton for their constant guidance throughout the experiment; to Mrs. Madeline Blackwell for preparation of the graphs; to the staff of Central Technical Department for their kind assistance; to H. L. Field, West Virginia Pulp & Paper Co., for the supply of northern woods; and to S. P. Kaptain, Southern Woodlands Div., St. Regis Paper Co., for the supply of southern hardwoods.

Experiences with Molded Fiber Sizing

N. F. RAUSCHER

During the past few years, the molded fiber industry has grown considerably in the United States. The production of molded fiber products is that portion of the paper industry in which individual articles are formed under vacuum in approximately their finished shape, and dried either by hot air or between heated dies; as compared to making a sheet of board on a paper machine and stamping or pressing a shaped article from the board.

It is the writer's intent to cover a few of the methods of sizing these products with which he has had experience.

One of the big reasons for growth has been the increased usage of one-trip disposable eating plates used in mass cafeteria feeding or at home. Another has been the food prepackaging era brought about through the advent of supermarkets with their self-service departments in which meat is either packaged at the individual store or in a central packaging house involving prepackaging for a large metropolitan area or a number of States.

As these articles are formed in their final shape, anything from a flat board to an egg carton, it is, in most cases, only practical to add the sizing materials to the pulp slurry before molding—or as beater additions.

The application for which the product is to be used must be considered first, and the sizing developed according to this end use. Then a practical method of testing at the mill production level must be found to evaluate the efficiency of the size development from the driers.

For example, with our plain molded, hot air-dried trays, which are used in refrigerated (35 to 40°F.) meat packaging, it is essential that the tray be resistant to meat juices and moisture while maintaining a degree of rigidity during the time they are in use. Normal shelf life in most supermarkets is 2 to 3 days. These products weigh about 0.04 to 0.045 gram per sq. cm. The furnish is predominantly groundwood, with small percentages of sulphite or kraft generally added for additional strength.

As the trays are formed with an edge or lip, they have considerable inherent rigidity from this standpoint, but small amounts of wet strength will greatly enhance this performance feature.

We have found, through actual evaluation under packaging conditions, a test which will give us an indication of "sizing" when the product is delivered from the drier. This test has sometimes been referred to as a modified Cobb test, in that we use the side wall of the plate for our water container. A *tared* tray is filled with 70°F. water to a depth of approximately $^3/_8$ in. The water is allowed to stand in the tray for 30 min., after which it is poured out and the weight increase recorded. We have found that if this weight increase does not exceed a certain percentage of original tray weight, the product will perform the job required of it.

Two per cent paraffin wax, $^1/_2$ per cent dry rosin size addition, is being used to achieve these results. Stock pH must be maintained at approximately 4.5 to 5.0, with commercial grade alum being used as the precipitation or flocking media.

We have found that stock temperatures, ranging from 60 to 120°F. do not essentially affect the sizing level of the output product. I believe that this is mainly due to the majority of sizing resistance being obtained from the wax, with the rosin increasing the wax retention or the coverage pattern in the finished product.

Output moisture runs about 10% from the drier. If much drier, it tends to cause brittleness in the plate. If much wetter, the water resistance drops off appreciably. Aging tests have shown that the resistance level stays about the same as that delivered from the machine. Raising the wax content has been found to help in some instances.

In central packaging systems, which sometimes serve a number of States, these products are really given rugged treatment. For example, one firm places cut up chicken on a tray and places this unit in a film bag. Air is evacuated from the package, causing the film to take the curvature of the packaged chicken and the package sealed. These units are then packed in barrels with ice, and shipped away to distributing points. This evacuation "sucks" a lot of juices from the chicken, creating a rigidity problem not normally encountered.

If you heavily size, or even coat the tray to a point where penetration is inhibited, you have a large quantity of loose water floating around the package.

One manufacturer claims, that by partial replacement of the hydroxyl groups in the cellulose chain with phenol formaldehyde molecules, tray rigidity is maintained satisfactorily

N. F. Rauscher, Diamond Match Co., Plattsburg, N. Y.

even with over 100% increase in tray weight through liquid absorption.

Molded table plates for use at home or in the cafeteria, have, in recent years, been used more and more. These products, therefore, to gain any appreciable acceptance, have to be both water and grease resistant, at least for the normal eating cycle of 15 to 20 min.

In order to meet competition from pressed board plates which have a naturally smooth surface, these products are generally dried between heated dies under pressure to create a smooth surfaced plate.

By relatively hard sizing the plate with dry rosin size (2 to 3%) we have been able to make the product resistant to hot water up to its boiling point.

In order to develop this resistance, you have to control the product moisture from the drier. At this rosin level, you have to be near the moisture-free stage to hold back hot water effectively. However, the resistance will develop upon aging for 4 to 6 weeks before customer usage. It is desirable, however, to obtain this resistance upon delivery from the machine, as the customer usually gets the off quality product within 2 weeks if you happen to produce any before your inspection setup catches it.

We test water resistance, using 160°F. water, in essentially the same manner as the plain molded tray.

Experience has shown that high stock temperatures (110 to 120°F.) are very detrimental to this type of sizing, and that you will get complete soak through in a very short time unless corrected by further size addition or other corrective measures.

As our system is batchwise, weekend storage of rosin sized pulp gives no resistance to hot water when we start up on Monday morning. Under normal stock temperatures (70 to 80°F.) efficiency will be maintained for about 12 hr. Addition of more alumina ion does not seem to help, and the only rectification that we have found is to resize the pulp to make it acceptable.

Grease resistance, however, has been more difficult to obtain. For a long time it was felt that grease resistance could only be obtained through mechanical refining of the pulp to give a tight, closely formed sheet, or through the use of surface applied coatings. Mechanical fiber treatment causes production slowdowns, and coating of the formed product is usually costly, in that it is a single unit proposition.

Our grease test consists of placing a tray on a rack, pouring a 1/4-in. head of 160°F. Mazola oil into the plate, and observing show-through of the oil on the bottom of the plate. The government had a standard, at one time, of 30 min. penetration resistance to 160°F. Mazola oil for their disposable plates. We feel that resistance of 15 to 20 min. is usually sufficient, and even this might be high.

Application of various type waxes have shown very interesting and promising results. Evaluation has shown that paraffin waxes will give resistance to within 15 to 20° of their melting point. It is possible to get grease resistance up to about 135 to 140°F. using high melt paraffins. It has been our experience that incorporation of polyethylene, thus raising the melt point, only hinders rather than helps the plate's resistance.

Use of low melt point "petrolatum" type waxes seems to give no appreciable grease resistance to the product.

Use of high melt point (175 to 190°F.) microcrystalline waxes gives resistance to hot oils and greases up to approximately 10° of their melting point.

The resistance obtained at any given percentage of wax addition is a direct function of product weight per unit area. For example, to obtain 15-min. penetration at the 8% wax level, the weight has to be about 0.030 gram per sq. cm.; but, by adding 12% wax, the weight can be decreased back to 0.015 gram per sq. cm. and still obtain resistance.

Testing of the above product with room temperature oil, however, gave rather significant results. Whereas 160°F. oil resistance was over 15 min., 80°F. oil resistance was around 2 min. This gave rise to some serious considerations.

Tests were run using blends of paraffin and microcrystalline waxes at various ratios, and with total wax contents running up to 20% of the product weight, the object, of course, being an attempt to achieve the good points of both.

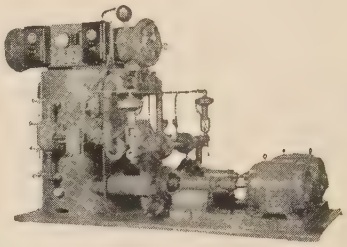
However, all results have been negative with these blended combinations giving neither hot nor cold oil resistance to any appreciable extent.

It appears that hot oil will go through the paraffin and the cooler oil through the microcrystalline phase. As for why, the only possible explanation that I can venture is that each wax might form a barrier or gel in the partial solubility range of the particular wax being used.

As you can well see, there are still many angles of fiber sizing which are thought provoking and challenging. However, I feel that knowing to what use the end product is being put, that through production and technical cooperation, the paper industry will continue to expand—whether it be paper or molded fiber.

An Empire State Junior Award paper presented at the meeting of the Empire State Section of the Technical Association of the Pulp and Paper Industry, Lake Placid, N. Y., June 9–11, 1955.

The ONE Vacuum Pump Made for Paper Mills



The Stickle Vacuum Pump is made exclusively for paper mills. It's easy to service. All floats housed in exterior float boxes. Interchangeable, removable vacuum chamber is above tank. Inspection of ejector tubes may be made without moving motor, pump or piping. Uses standard horizontal motor and pump. For vacuums to 28". Built-in heat exchanger eliminates costly cooling equipment. Recirculation of hurling water condenses flash vapors and releases air and gases to atmosphere. No close clearances to cause wear. Performance guaranteed. Single and duplex models. Write for free literature.

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Hotel Patten, Chattanooga, Tenn.

Oct. 19–21,1955

The Permanence of Paper in Temperate Climates

W. H. LANGWELL

In the following account "permanence" will be used to denote chemical stability and "durability" will be reserved to indicate resistance to wear and tear. No apology is needed for restricting these terms in this sense since paper technologists have for long made a similar use of them.

There can be no doubt that paper can be one of the most permanent materials known to man—papyri more than 3000 years old can be seen in museums. At the other end of the scale some cheap papers made about 1880–1890, probably stored in a gas lighted library, became brittle in a few years.

About 1800 the printing press began to outstrip the productive capacity of the craftsman papermaker and paper of poor quality began to appear in quantity (*4*). About 50 years later the Industrial Revolution in Great Britain had got into its stride and atmospheric pollution became severe. The period 1880–1900 coincided with the use of somewhat impure coal gas for indoor lighting and in a badly ventilated library relatively very high concentrations of sulphur dioxide could and no doubt did develop. Twenty years later electricity was rapidly displacing gas for this purpose and one source of indoor pollution began to diminish in severity. Between 1900 and the present time atmospheric pollution has remained with us to a scarcely diminished extent and no industrial country is free from its effects (*11*). Complaints about the impermanence of paper became insistent about 1890 and have continued ever since that time (*4*). The first complaints were directed at the papermaker who was accused of using inferior materials and unsatisfactory processes, and specifications were drawn up to make sure that government departments dealing with important documents could obtain reasonably permanent paper. The first specifications were based on the assumption that permanent paper must consist as nearly as possible of nothing but alpha-cellulose; other less highly polymerized forms of cellulose, hemicelluloses and lignocelluloses, being supposed inherently impermanent (*1, 3, 6, 8, 9*). This assumption has been challenged (*4, 5*). It certainly would not account for the permanence of papyrus which contains a large proportion of low polymer celluloses and hemicelluloses (*10*).

Furthermore timber which is a mixture of a large variety of celluloses and hemicelluloses is normally exposed to the rigors of the weather in addition to the polluted atmospheres of our industrial centers and is known to have survived for hundreds of years without serious damage. The well-known heat test was devised to enable paper technologists to predict which kinds of paper would be likely to be permanent in use, and this test is still the only established experimental guide to the selection of paper for important archives. This test which consists in heating a paper sample to 100°C. for 72 hr. in a moving current of air was very thoroughly investigated by Rasch of the National Bureau of Standards who tested several grades of paper by this method and examined the heated samples for reduced resistance to folding, for increase in copper number, and decrease in alpha-cellulose content (*2, 6*). On the whole the results showed that high quality papers were more resistant to the test conditions than the cheaper papers made from chemical and mechanical wood pulp. The indications were plausible. Nevertheless, in spite of this, it was believed in some quarters that at least some of the papers made from chemical wood pulp would be reasonably permanent but there was no alternative aging test with which to support this belief. The fundamental assumption underlying the heat test is that mere exposure of paper to the atmosphere is sufficient to bring about some chemical degradation of the fiber of the paper and that by working at an elevated temperature the process of deterioration can be speeded up so as to give measurable changes in 72 hr. This assumption has never been given a satisfactory experimental basis and the heat test still rests on its plausibility only. It would almost certainly detect a badly made paper, e.g., one containing appreciable amounts of excess acidity, by accelerating the destructive action of the acid (*5*). Apart from this there is a suspicion that it really tests the *durability* of papers by mechanically weakening them so that an initially weak paper will fail long before an initially strong one. In any case experimental data now exist which makes it seem more probable that the commonest kind of chemical deterioration in paper is due primarily to the action of sulphur dioxide in contaminated air and not to oxidation by the oxygen in normal air (*7, 11*). If books stored in a contaminated atmosphere for a few years be examined it will almost always be found that the edges of the pages will contain much more sulphate than the centers even when embrittlement has not proceeded to a noticeable degree. Where marked embrittlement has taken place it is almost always confined to the outer half inch or less of the page; the center of the page, even with newsprint, being practically undamaged (*11*). It is difficult to explain this kind of difference except by assuming that the outside edges have absorbed some constituent from the atmosphere and have been damaged in the process. That this constituent cannot have been oxygen is evident from the undamaged state of the interior of the page (*11*). The latter, therefore, in effect serves as a good control for the analysis of the edges and the difference in the amount of sulphate found in the two samples indicates the amount and source of the damage. This is to some extent confirmed by the observation that the edges of the pages also contain much more ammonia than the centers (*11*). Support is lent to this explanation by the fact that an ash-free filter paper and a shaving of wood containing practically no heavy metals do not accumulate sulphate when exposed to an atmosphere containing sulphur dioxide while the filter paper impregnated with small amounts of such catalytically active metals as iron, copper, and manganese shows a rapid accumulation of sulphate under similar conditions (*11*). All these experimental data strongly suggest that sulphur dioxide is the real cause of the impermanence of paper in temperate climates and that traces of catalytic metals in the paper cause the oxidation of the sulphur dioxide in the atmosphere to sulphate which accumulates in the paper as the relatively nonvolatile suphuric acid or as ammonium sulphate and usually both. In bad cases as much as 1% of sulphate reckoned as sulphuric acid has been found in the edges of the pages of books mostly in the form of free sulphuric acid (*11*). It is not surprising, therefore, that the paper becomes brittle and there seems to be no need to assume that any other agent is significantly active. As a result of these findings an entirely new type of accelerated aging test is now proposed. It is based on the liability of paper to accumulate sulphate in an atmosphere containing about 0.5% SO_2 and excess of free oxygen.

PROPOSED STANDARD ACCELERATED AGING TEST

Samples of the paper in the form of strips about 2 in. wide and long enough to weigh 1.00 gram air dry are reconditioned between damp blotting paper to a weight of 1.10 grams when they are folded concertina wise and placed in 4 by 1 in. flat bottomed sample tubes. A standard type 1-1b. domestic Kilner jar with air tight closure is used as a container for three sample tubes (Fig. 1). The jar contains the following solution freshly made up:

Water	50 ml.
Potassium metabisulphite	2.5 grams
Potassium ferrocyanide	0.1 gram

W. H. Langwell, The Garth, Windmill End, Epsom, England.

and the three samples in their tubes immediately placed in the jar which is then quickly closed and kept in the dark at room temperature for 7 days. At the end of this period the samples are removed from the jar and analyzed for sulphate by the gravimetric barium sulphate method. Unless the temperature is controlled during the 7-day standing period each jar should include one control sample and two test samples, e.g., one treated and one untreated sample. The metabisulphite solution maintains a constant small concentration of sulphur dioxide in the atmosphere of the jar of approximately 0.5% which is about 5000 times the normal concentration of sulphur dioxide in an urban atmosphere. The ferrocyanide prevents the oxidation of the metabisulphite solution which might otherwise tend to consume the limited amount of oxygen in the atmosphere of the jar. The results are simple to interpret. The variation in the amount of sulphate found in the controls after exposure shows the effect of temperature variations from jar to jar. The increased sulphate in the untreated sample will indicate the liability of the paper to damage. If the treatment has been effective the treated paper sample should show only as insignificant increase in sulphate after exposure.

Having an accelerated aging test which seems to imitate fairly closely the natural course of aging in a normal urban atmosphere it proved to be easy to find simple and effective methods of treatment which would completely prevent the formation of sulphuric acid in the paper and in this way make the paper proof against the action of atmospheric sulphur dioxide. Bearing in mind that two factors must operate together to cause this kind of embrittlement, viz. catalysts in the paper and sulphur dioxide in the air, certain possible and practicable methods of preventing embrittlement immediately suggest themselves.

1. Removal of catalytic metals from the paper or the preparation of paper free from metallic impurities.
2. Addition of buffers or basic substances to the paper.
3. Sealing up the paper by enclosing it in containers or by covering it with an impervious layer of varnish or foil as, e.g., by lamination with cellulose acetate foil.
4. Destroying the catalytic activity of the metallic impurities in the paper by means of catalyst poisons or other inhibitors.
5. Storing the paper in an atmosphere free from sulphur dioxide as is sometimes done in libraries by the use of special air conditioning plant.

Most of these methods have their advocates and one or other of them should be able to satisfy most of the conditions which are likely to arise in practice. Method 4 is at present being developed on the laboratory scale by the author and it now seems probable that a very simple and effective procedure based on the use on inhibitor solutions will result. With most commercial writing and printing papers it is only necessary to soak them for 30 min. in an excess of a 1% solution of a complexing agent, such as for example, the disodium salt of ethylene diamine tetra-acetic acid and dry at low temperature to produce a paper which appears to be quite immune to damage by atmospheric sulphur dioxide under any normal conditions of use (*12, 13*).

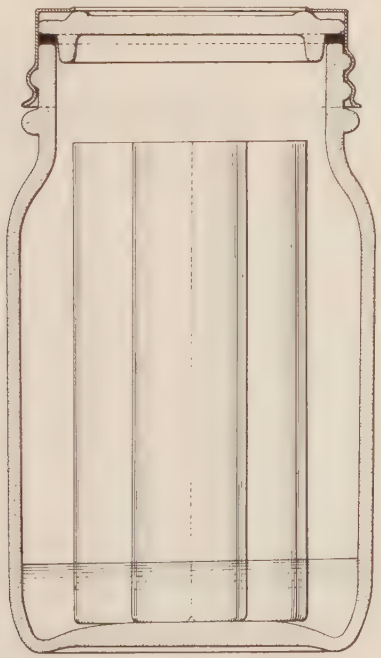

Fig. 1

Table I

Sample	*Inhibitor*	*Amount of inhibitor, percentage of air-dry sample*	*Sulphuric acid gained, percentage of air-dry sample* No inhibitor	With inhibitor
Sulphite pulp	None	...	0.07	...
Newsprint	Ethylene diamine tetra-acetic acid (EDTA)	0.50	0.38	0.04
Newsprint	Potassium ferrocyanide [$K_4Fe(CN)_6.3H_2O$]	0.50	0.42	trace
Imitation vellum	EDTA	0.50	0.46	0.46
Imitation vellum	Potassium ferrocyanide	0.50	0.29	0.04
Whatman thick handmade	EDTA	0.50	0.71	0.29
Whatman thick handmade	Potassium ferrocyanide	0.50	0.92	0.33
Strawboard	EDTA	0.50	1.01	1.01
Glassine	EDTA	5.00	1.34	trace
		2.50	1.34	0.08
		1.25	1.18	0.21
		0.63	1.18	0.34
		0.50	1.34	0.65
Glassine	Potassium ferrocyanide	5.00	1.60	0.25
		0.50	1.32	0.59
Glassine	Disodium dihydrogen pyrophosphate [$Na_2H_2P_2O_7$]	5.00	1.60	0.17
	Potassium oxalate [$K_2(CO.O)_2.H_2O$]	5.00	1.43	1.55
	Sodium citrate [$Na_3C_6H_5O_7.5H_2O$]	5.00	1.43	1.09

Table I shows the kind of results obtained by the use of complexing agents with a few bookbinding materials. Much improved results have more recently been obtained by the author and most of the anomalies removed in a more recent investigation, the results of which are shortly to be published.

In view of these results there remains little doubt that atmospheric damage to paper can be serious and can be reduced to a negligible amount and that almost any kind of paper can be rendered permanent enough to be used for archives with a probable life of hundreds of years provided that mechanically weak paper, such as newsprint, is not called upon to withstand much handling without reinforcement by some means such as lamination. The strong handmade tub sized papers, when treated with inhibitor will, of course, always be preferred for archive work because they will then possess outstanding qualities of both permanence and durability.

In conclusion, while it is difficult to forecast the composition of urban atmospheres beyond the immediate future, it does seem probable that we shall have to count on sulphur contamination for at least a hundred years longer. If this is so, then paper records will need protection for at least this period and the treatment with inhibitors which has been outlined should be amply sufficient to ensure immunity for this period.

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Guide for Physicians Concerned with Hearing Conservation in Industrial Noise*

THE purpose of this guide is to acquaint the industrial physician with the practical aspects of the noise problem as encountered in industry.

In the interests of hearing conservation, physicians will be consulted more frequently in the future regarding this problem. The information contained in this guide is based on research and clinical experience. These opinions represent our best knowledge as of May, 1952. As more research data and experience are accumulated, these opinions may be subject to change.

GENERAL INFORMATION

The effects of noise on hearing depend on the following factors: (1) individual susceptibility, (2) length of exposure to noise, (3) the characteristics of the noise, and (4) noise intensity.

In general, the probability of damage within a short time is very high for noises at levels of 120 to 130 decibels or more; ultimately for levels of 100 to 120 decibels, and certain noises at levels of 90 to 100 decibels may produce damage in highly susceptible individuals.* The figures stated in this guide are merely suggestions for the industrial physician and, as yet, do not constitute legal, medical, or engineering standards.

High noise levels may cause permanent impairment of hearing by irreparable damage to the inner ear. There is no known method of repairing the delicate structures injured by noise. Noise usually causes more loss of hearing for high pitched tones than for low pitched tones. In the beginning most or all of the hearing loss is for tones above those important to the understanding of speech. Therefore, early damage is unnoticed. Noise injures some ears more than others.

Early losses in hearing due to noise are not noticed by the individual and can be detected only by accurate pure tone audiometric evaluation. This loss usually occurs first in the high frequencies and is most often noted in the area which extends from 3000 through 6000 cycles per sec.

Hearing loss due to noise in the presence of continued exposure to high noise levels will progress to involve the speech frequencies. When this occurs the individual becomes aware of his hearing loss. This progression may continue to an advanced stage, resulting in a severe handicap. This tragic sequence of events may be prevented by adequate testing and protective measures.

Normal hearing is a priceless asset. Loss due to noise is one of the few types of hearing impairment which can be prevented. Testing measures consist of accurate pure tone audiograms before employment and routine periodic recheck audiograms. Recommended test frequencies should include the following: 500, 1000, 2000, 3000, 4000, 6000, and 8000 cycles per sec.

Protective measures include steps to reduce noise at its source, such as reducing the machinery noise, and/or acoustical treatment of the surrounding area. Noise at the ear can be reduced by the use of ear plugs, ear muffs, or a combination of both.

PERMANENCY OF LOSS DUE TO NOISE

Hearing loss due to noise may be temporary or permanent. It may be considered permanent if it still persists after the individual has been removed from the noise environment for a period of 6 months.

Before any hearing loss is considered permanent, a minimum of three audiometric tests should so indicate; these tests should be done on separate days at similar times and under analogous conditions.

DIAGNOSIS

Hearing loss due to noise is difficult to differentiate from that due to other causes of inner ear impairment such as systemic disease, toxicity due to infection, effects of drugs and presbycusis.

All means of differential diagnosis should be used before establishing the diagnosis of hearing loss due to noise. This includes a complete history with special reference to any previous hearing tests, a medical examination, accurate pure tone bone and air conduction audiometry, and complete speech reception and discrimination tests.

Trained personnel under the supervision of a physician may measure hearing. It is the responsibility of the physician, however, to determine and evaluate the degree of hearing loss.

The determination of compensation for loss of hearing, however, is not the responsibility of the physician.

REHABILITATION

Hearing loss due to noise as well as other causes of inner ear impairment may become a severe handicap. Rehabilitation measures are advisable in these cases. Such measures include speech reading (lip reading), auditory training, with or without a hearing aid, and speech conservation. Such a program of rehabilitation will prove of definite benefit to the handicapped individual.

Issued by the American Academy of Ophthalmology and Otolaryngology, Subcommittee on Noise in Industry of the Committee on Conservation of Hearing.

* The levels referred to are determined by the use of a standard sound level meter having a zero reference level of 0.0002 dyne per sq. cm.

Methods for Preparing and Presenting Requests for Project Approval

E. K. MURPHY

IT IS quite normal for a good engineering report to be the basis on which a chief engineer will decide that a given capital project merits his recommendation. Such a report, usually staff-prepared, will include a statement of the problem with supporting background information, possible and recommended solutions, and the estimated cost of putting the recommendations into effect.

If the report stops at this point, it is in poor shape to receive management consideration since the technical soundness of a project does not qualify it for a place in the budget; it must also be economically worthy.

All too often, the engineering report is supplemented by a written or verbal presentation which does not add new data but which emphasizes that the project is a "must," that the only alternate is disaster; or that nothing less than the whole project will do; or that the long-term project must be handled

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on an inflexible schedule. In addition to these, there are also the promotional types of presentation, based on charm and salesmanship, which have had their share of success.

Fundamentally, none of these approaches properly assist management in making a fair evaluation of just what the project can contribute to the well being of the company. Let us look at it from their viewpoint. Among many other duties, management has the finite responsibility for seeking an adequate return on the capital which has been invested in the company. If this responsibility is handled well, a good relationship will exist between expenditures and earnings, and it follows that the company will prosper.

In discharging this particular responsibility, management is constantly faced with the problem of where to place its limited capital funds. As a general statement, these funds are made up of retained earnings plus depreciation which, on an annual basis, become the capital budget. Since an alert organization will invariably produce more ideas than can be developed within this capital budget, it is inevitable that management will screen the projects submitted for those which will pay the highest evaluated return consistent with the growth of the company.

Each company will tend to develop its own yardsticks for determining whether or not a given project passes the tests imposed by the capital budget. There is one yardstick, however, that is common to all such budgets, and that has to do with rate of return; directly or indirectly, this factor is always considered. A project should show earnings or savings at least as high as the company has been realizing on retained earnings. With industrial stocks paying 4 to 6% dividends, and realizing that expanding companies seldom pay out more than 40% of earnings as dividends, a return of 10 to 15% after taxes is needed if the project is to carry its share of the dividend payment.

With these considerations in mind, it should be obvious that an engineering report is of most value to management if it contains the complete basic data upon which economic conclusions may be drawn. Such data will include costs and earnings of any pertinent existing installations as well as those same factors regarding worthy alternates and the recommended solution. Having a report with this information, the chief engineer can make his own initial economic evaluations, determining if the technically sound project measures up to the minimum capital budget yardsticks. If it does not, he will be well advised to drop the project right there unless he feels that there are some important extenuating circumstances which should permit waiving the normal economic requirements.

EVALUATION OF CAPITAL EXPENDITURE PROJECTS

There are many methods for evaluating capital expenditure projects and the engineer needs the guidance of his management in determining which to use for computing profit potentials. The engineer should become thoroughly familiar with the methods his company prefers and in addition have some knowledge of others, if for no other reason than to recognize when a given approach will put his project in an unfair light. Some of the better known methods in current use are:

1. *The Pay-Back Method* evaluates the number of years it will take gross earnings or savings to repay the original expenditure. It has the advantage of directly relating capital expenditure and gross cash earnings, concentrating on the known near years. It has the disadvantage of ignoring net profits, salvage value, and restricted production, as well as the long-term possibilities of an improved rate of return. This approach has its highest value when used as a screening device. In this industry, 5 years tends to be the maximum pay-back period to qualify a project.

2. *Capital Ratio* is another rule of thumb evaluation, useful where the project can be tied in to a known sales program directly related to the project. The ratio is expressed as follows:

$$\text{Capital ratio} = \frac{\text{Capital expenditure}}{\text{Annual gross value of sales}}$$

In the pulp and paper industry, the maximum acceptable ratio tends to be in the bracket from 1.5 to 1.6.

3. *Rate of Return*, straight line basis, is an approach which provides a relationship between capital expenditure and net earnings. This method takes average annual earnings over the life of the project, after subtracting straight line depreciation, and compares the result to the initial capital investment or to the total average investment (total outlay for nondepreciating assets plus one-half outlay for depreciable assets). The resulting percentage is the rate of return. This approach has the good point of recognizing net earnings, but requires long-range economic forecasting and is therefore insensitive to changing conditions such as tax rates and new technology.

4. *Rate of Return*, discounted cash flow basis, is similar to (3) above except that discount rates are applied to all cash flows, and distant flows being discounted to a greater extent than the near cash flows. The advantage of this approach is that it recognizes that greater weight should be given to projects which produce the bulk of their earnings in the near years.

If the project is small, the pay-back method may suffice. However, as projects become large enough to constitute a perceptible part of the budget, a more accurate study is warranted if correct conclusions are to be drawn.

A report which is complete in both engineering and economic aspects is apt to be technical and voluminous. The management committee passing on expenditures will often be unwilling or unable to take the time required to study such a lengthy work. This being the case, it is advisable to prepare a summary or digest of the report which will give the bare outline of the problem, the recommended solution and its estimated cost, earnings, and rate of return.

The digest becomes the presentation, with the report to back it up in any discussions of recommended or alternate solutions. The report is also available, of course, for those on the management committee who might want to study the details of the project.

With the digest assuming such importance as the vehicle of presentation, there is considerable merit to the thought that the chief engineer should prepare it himself, using the report as the reference. This has the specific advantage of insuring that the chief engineer is thoroughly familiar with the details of the report and should therefore be in a good position to easily and quickly answer questions which come up in the course of presentation.

REPORT FORM

To best illustrate the principles discussed, we can invent a mythical paper mill and draft the outline of a report on a proposed departmental expansion. Let us assume that this mill is an operating unit with an annual production of 60,000 tons of product having a current selling price of $100 per ton. Current annual expenses are $4,800,000 and current annual income taxes are $600,000. Because of its age, no further depreciation of the mill's present after-tax-disposal value of $2,400,000 need be considered. The problem is whether or not to modify the bleach plant capacity to improve product grade.

With this as a background, the suggested form of report is outlined as follows:

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Foreword	—
Proposed solution	—
Estimated costs and earnings	—
Conclusions	—
Recommendation	—

ENGINEERING REPORT

1. Introduction —
2. Existing conditions —
3. Available solutions —
4. Special considerations —
5. Economic considerations —
6. Design considerations —
7. Recommended solution —
8. Plan of execution —

DIGEST OF REPORT ON
PROPOSED BLEACH PLANT MODIFICATIONS

Foreword

Limited to 100 words, the foreword should establish the background of the project, including general description of physical, operational and economic conditions of present facilities.

Proposed Solution

Outline general approach, equipment and buildings involved, process changes, manpower requirements.

Estimated costs and earnings

Investment:

	Added investment	*Total commitment*
Present operation	0	$2,400,000
Proposed modifications	$700,000	3,100,000

Net earnings	*Total sales*	*Operating expense*	*Income taxes*	*Net profit*	*Added net profit*
Present operation	$6,000,000	$4,800,000	$800,000	$400,000	$400,000
Proposed modifications	6,500,000	5,000,000	900,000	600,000	200,000

Estimated return on investment of $700,000 is 22% on 10-year discount cash flow basis. (*Note:* Although a 20-year write-off would be more realistic in this instance, the 10-year figure is used here for sake of brevity.)

Conclusions

1. Engineering risks: New process with some risk of delay in start-up; no risk of failure.
2. Present production: Can be maintained with little interruption during proposed construction.
3. Project completion: 8 months.
4. Extenuating circumstances (if straight economic approach not applicable, state reasons).

Recommendations

Project is recommended for approval on basis of improved product to be obtained, with adequate return on investment.

(Digest should be limited to two single-spaced pages)

ENGINEERING REPORT

(Double spaced)

1. Introduction

Limited to about 300 words, establish the background of the project, including general description of the physical, operational, commercial, and economic conditions which lead to this report. Scope should be established, stating any limitations or boundaries of investigation which may have been imposed.

2. Existing Conditions

Expand the general background description as outlined in the Introduction, developing the specific technical or commercial reasons why the project is being considered.

When physical conditions or layout are poor, sketches, prints, or photographs can be included in this section as supporting evidence.

If a new facility is to be recommended, involving a net increase in company-wide capacity, this portion of the report can point out the difficulties or impracticability of expanding or adding to existing facilities.

Should this be a replacement project, the condition of existing equipment, its operating costs and the quality of its output must be stated in detail.

3. Available Solutions

Available or alternate solutions should be listed, with a sentence of dismissal for those considered impractical. Usually from two to four alternates are available which may be worthy of consideration and each of these should be outlined in sufficient detail to provide a clear picture of the major points involved. Invariably there is the basic alternate of doing nothing; the ramifications of this default type of approach must also be reviewed.

4. Special Considerations

There will be exceptions to the rule that all projects should be justified on a straight economic basis. Where this is felt to be the case, the special considerations may be outlined here, emphasizing long-range potentialities which also have economic merit. Some of the recognized exceptions are:

1. Introduction of a new product. Long-term development of the market may delay adequate return on investment.
2. Protection of a market or meeting competition.
3. Production of a material or service for internal use. Lower rates of return often acceptable in such instances because it may be necessary to protect the main investment.
4. Expenditures for research or for research facilities.

5. Economic Considerations

This portion of the report should be devoted to a detailed economic comparison of existing conditions, the several worthy alternates and the recommended solution.

The existing installation or method should be examined first. Often it is desirable to determine the disposal value (after taxes) of the existing equipment or facilities, for this represents the capital investment if present conditions are continued. Present gross revenues, reduced by present or future estimated operating expenses, represent gross earnings. From these data return can be calculated.

The remaining alternates and the solution to be recommended should in turn be similarly examined, preferably in the order of amount of capital investment involved. The study of each possibility should be in considerable detail, establishing good data on estimated investment, operating costs, revenues, and return.

There should be a summary sheet for this section of the report. The minimum investment alternate, with its associated estimated revenues, expenses, and returns, should head the list and become a base for comparison. The next alternate involves an increment of investment over the first alternate and the data now available permit calculation of the return on the increment. Proceeding through the alternates in this manner, a pattern of return can be established showing the point at which added capital investment does not bring a satisfactory added return. Selection of the recommended solution is now rather simple unless there are other factors which should over-rule the straight economic approach.

In a report of this nature, a single economic approach is normally sufficient. However, to illustrate the various possibilities, all of the methods previously described are outlined below, using the example of the same mythical paper mill.

Since the example to be used involves increasing the selling price of the mill's production, the authority for the increased value of the product should be quoted; in a case such as this, it would probably be the sales department or an independent consultant.

The summarized data on the mythical paper mill and its proposed modification are as follows:

Investment Comparison:

	Present investment	*New capital*	*Total investment*
Present operation	$2,400,000	0	$2,400,000
Proposed operation	0	$700,000	3,100,00

Earnings Comparison:

	Total sales	*Operating expenses*	*Income taxes*	*Profit*[a]
Present operation	$6,000,000	$4,800,000	$800,000	$400,000
Proposed operation	6,500,000	5,000,000	900,000	600,000

[a] After taxes, but before depreciation. Assume 10-year life of proposed modifications.

Evaluation:

A. Pay-Back Method. The estimated profit of $200,000 would pay off the $700,000 investment in 3.5 years. This compares favorably with the 6 years which would be required for the $400,000 profit on the present operation to pay off the mill's current disposal value.

B. Capital Ratio.

$$\text{Ratio} = \frac{\text{Investment}}{\text{Sales due to investment}} = \frac{\$700,000}{\$500,000} = 1.4$$

The value of 1.4 for this ratio must be compared to company experience with other capital expenditures to determine if that ratio has provided an acceptable profit ratio in the past.

C. Rate of Return, straight line basis.

(1) Compared to initial investment, and deducting 10% of investment for depreciation, net profit on added investment = $130,000/$700,000 = 19%.

(2) Compared to average investment, and assuming all assets are depreciable, net profit on added investment = $130,000/$350,000 = 37%.

Both the 19% and the 37% rates look acceptable when compared to the 16% return on the present $2,400,000 investment.

D. Rate of Return, discounted cash flow.

(1) If the $200,000 annual return is constant for each of the the 10 years, the rate of return can be calculated by treating the investment on a mortgage basis; i.e., use the $200,000 as an annual payment for 10 years to pay principal and interest on the amount outstanding. The following expression can be used for this purpose:

$$P = R\left[\frac{(1+i)^n - 1}{i(1+i)^n}\right]$$

where P represents the present worth of all payments, R is the annual installment, i is the rate of interest, and n is the number of years for mortgage pay-off. In the case at hand,

$$\$700,000 = \$200,000\left[\frac{(1+i)^{10} - 1}{i(1+i)^{10}}\right]$$

Solving, $i = 25\%$, which compares favorably with the 16% applying to the present investment. (Note that payments and compounding of interest have been made on an annual basis; if done more frequently, interest rate would be slightly higher.)

(2) The real benefits of this method appear in a more pronounced manner if the $200,000 return represents an annual *average* of the total 10-year return. The table below lists the manner in which the net return (before depreciation) might vary over the life of the project. Here again, we can treat this as a mortgage, with the interest and principal being paid with each available annual return. The expression for determining the amount of principal which can be repaid with each annual installment is

$$S = P(1+i)^n$$

when S represents the total sum to be paid at the nth year, P the present worth of that sum, and i the interest rate. In the case at hand, the interest rate works out to 22%, a favorable figure compared to the 16% on present investment.

Year	S[a] *Total payment*	$(1+i)^n$ *Interest factor*	P *Payment on principal*
1	$ 50,000	1.22	$ 41,000
2	160,000	1.49	107,200
3	200,000	1.82	110,000
4	250,000	2.22	112,600
5	250,000	2.70	92,500
6	250,000	3.30	75,800
7	230,000	4.02	57,200
8	230,000	4.91	46,800
9	200,000	5.99	33,400
10	180,000	7.31	24,600
Total	$2,000,000		$701,100

[a] Average annual value of S is the $200,000 used in previous computations.

Note that effects of delayed returns are properly accounted for in this method; also that great weight is given to near cash flows and near estimates, while greatly reduced weight is given to distant parameters. This approach provides a superior evaluation and should be used wherever possible.

6. Design Consideration

Special design features associated with the recommended solution should be outlined, complete with reasons as to why these features are desirable. This may include references to site, equipment, materials, process requirements, methods, special techniques, and any unusual technical problems.

7. Recommended Solution

The recommended solution should be summarized with a statement of the reasons for its selection. Simple drawings or sketches of a general nature are desirable in this section of the report.

8. Plan of Execution

Describe methods to be used for desired factors such as speed of completion, minimum interference with existing production facilities, cooperation with public bodies. Plans for contracting or subcontracting work at the site should be stated.

An estimate timetable should be included here, such as the following:

Project Timetable

	Weeks after approval date
Design 70% complete	. .
Drafting 70% complete	. .
Start ordering equipment	. .
Field work starts	. .
Design 100% complete	. .
Drafting 100% complete	. . .
Finish ordering equipment	. . .
Equipment deliveries complete	. . .
Construction and erection complete	. . .
Coordinated trial operation starts	. . .
End of trial operation period	. . .
Follow-up report of actual economies effected as compared to estimated economies	. . .

LITERATURE CITED

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2. Ulin, R. P., *Chem. Eng.*, Vol. 61, No. 4: 347 (April, 1954).

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Fifth Corrugated Containers Conference, Morrison Hotel, Chicago, Ill., October 5–7, 1955.

Twelfth Agricultural Fibers Conference, Alton, Ill., October 13–14, 1955.

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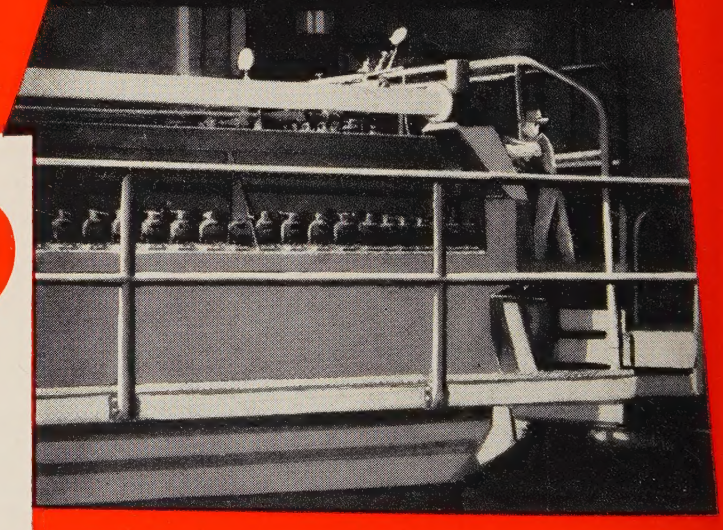

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